SEPTEMBER 28, 1959

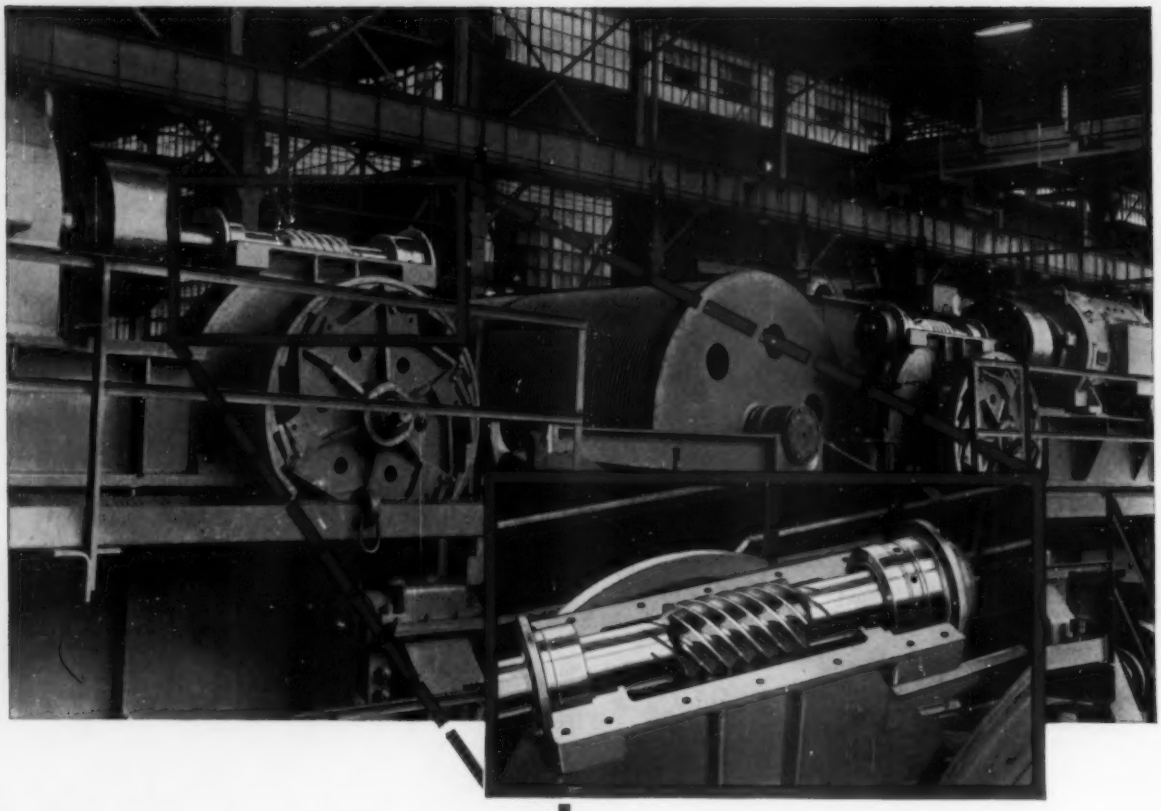
PRICE 50 CENTS

Product Engineering

DESIGN issue

McGRAW-HILL WEEKLY

How aluminum finishes ... see page 5



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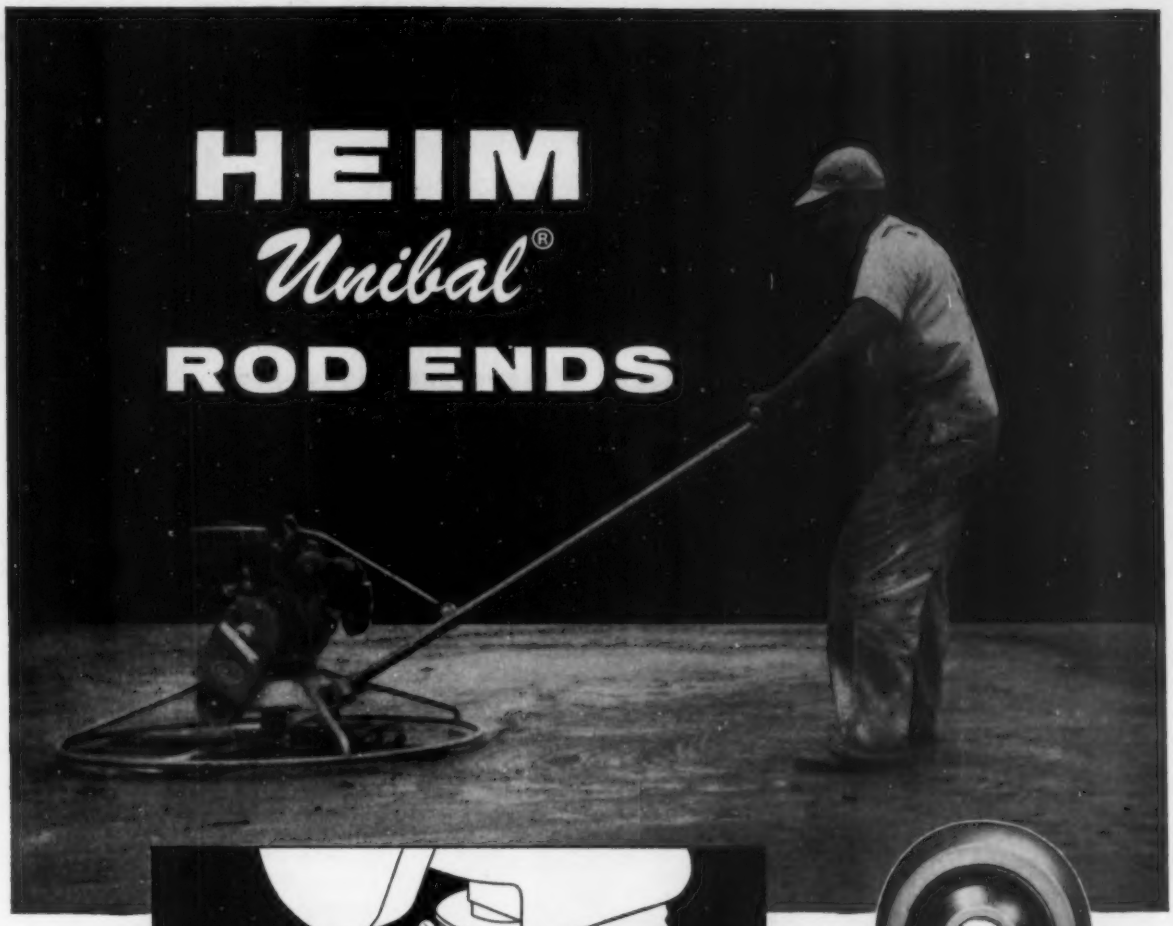

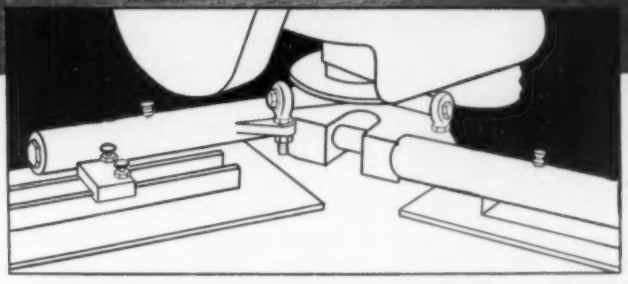

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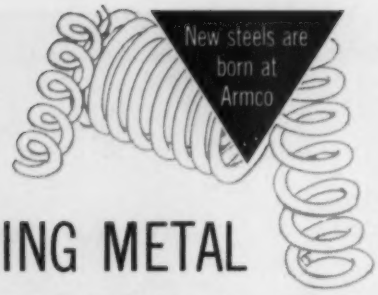
CIRCLE NO. 1 READER SERVICE CARD 1



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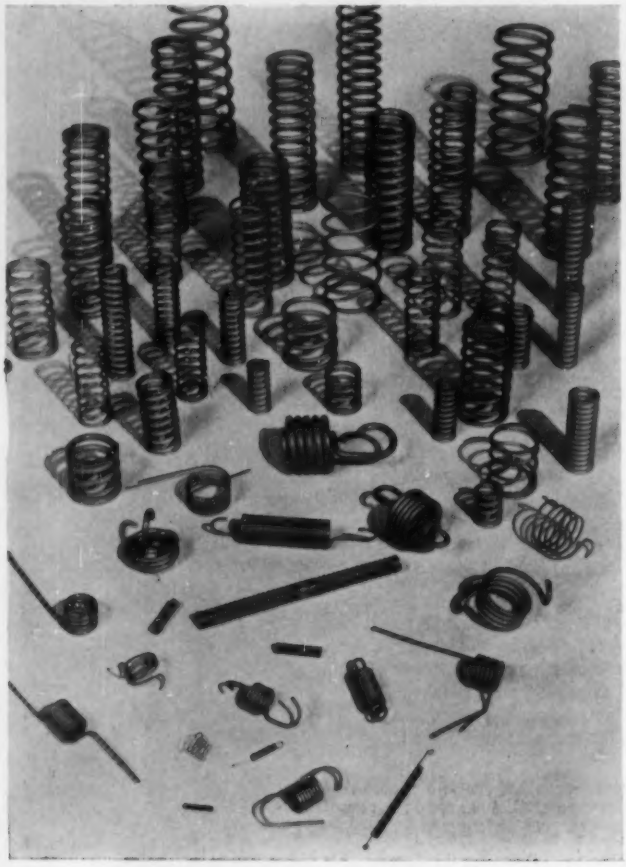

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Product Engineering

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

DESIGN issue

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Interesting to Note . . .

Aluminum's Other "I"

When Charles Martin Hall's chemistry professor announced in class that fame and fortune awaited the man who could develop a low-cost method of separating aluminum from its ore, the student's mental wheels began to turn. Young Hall worked diligently in his home laboratory and in 1886, patented his famous process for obtaining aluminum by electrolysis. The seeds of a giant industry had been germinated; all that 22-year-old Hall needed was money. He journeyed to Pittsburgh where he convinced a group of backers headed by Capt. A. E. Hunt and Romaine C. Cole, to put up $20,000 for a small pilot plant that would put the Hall process to the test. The newly established group called itself the Pittsburgh Aluminium Co.

An apocryphal story relates that a Pittsburgh printer accidentally dropped the second "i" in the word "aluminium" on the company's new stationery—and that, rather than spend $300 to reprint the stationery, management let "aluminum" become official spelling for both company and product. This story is doubtful because the struggling young company could ill afford $300 for stationery. Anyway "Pittsburgh Aluminium Co" lasted only two weeks as a name. Next name was Pittsburgh Reduction Co. This one gave trouble too. Some people thought the company was a garbage-disposal firm. Once, a confused individual roused a company official from his sleep to complain that the company had not removed a dead horse from a nearby alley. In 1907 the last name-change was made, this time to the Aluminum Company of America.

Research has always been important to the firm. Thirty years ago, an Alcoa scientist, F. B. Flick, became first American to patent a process for anodizing and coloring aluminum. As our cover shows, many improvements have since been made and you can get various anodized aluminums, depending on the specifications (p 44).

Mystery at Uto Island

With Space Age technology requiring more and more engineering know-how, it is often refreshing to look back on how our forefathers managed to answer the mysteries of science that confronted them. One case in point required the patience of a Sherlock Holmes to get the answer which, in turn, has helped those scientists of today

CONTINUED ON PAGE 7

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ABP ABC

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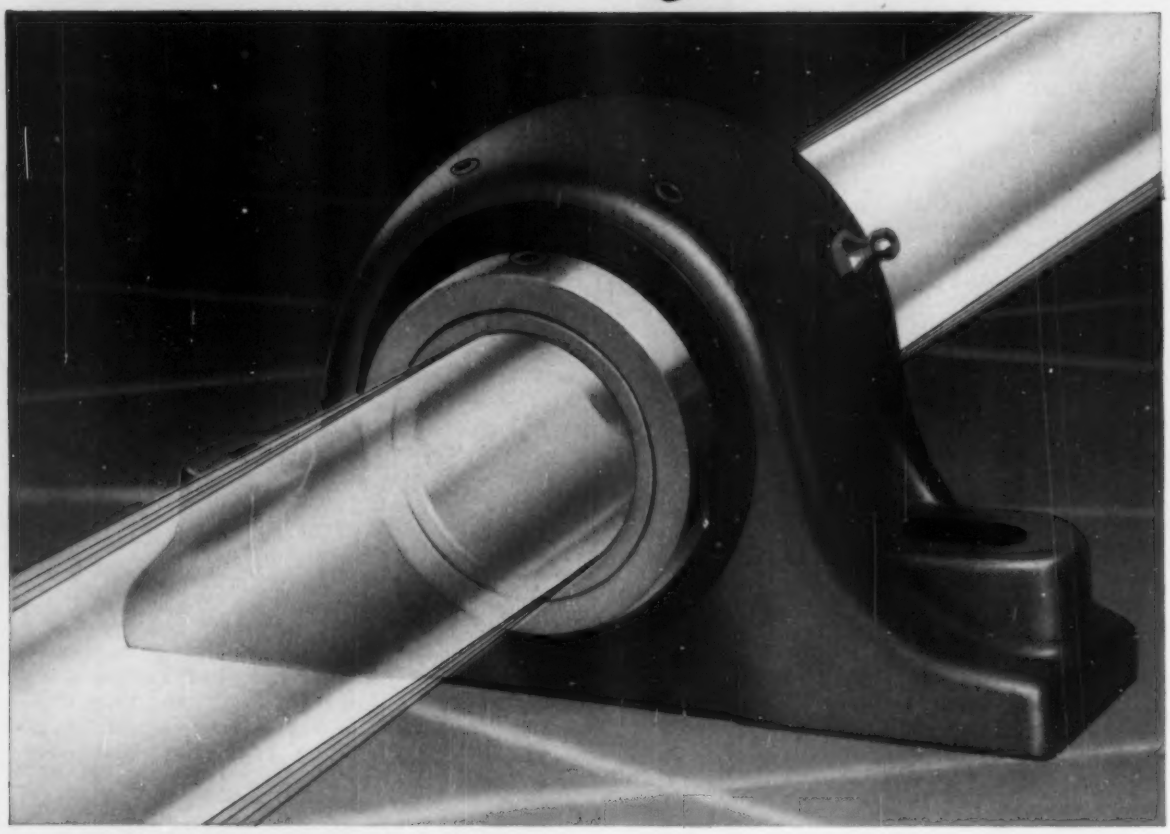

Link-Belt roller bearings compensate for misalignment of shafts and supports

Link-Belt Series 400 roller bearings have won a reputation as "the designer's choice." These self-aligning, double-row roller bearings compensate for inaccuracies in machining and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

For complete information on the Series 400 —and Link-Belt's complete line of ball and roller bearings—send for our Book 2550. It's available at any one of the 40 Link-Belt offices.

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who need lightweight metals for space exploration.

The mystery began on the tiny island of Utö, in the Baltic Sea off the Swedish coast. Around 1800, the Brazilian explorer, José Silva, found a mineral called petalite on the island but his discovery attracted little attention. In 1817 meallurgist E. T. Svedenstjerna went to the island and brought pieces of petalite to the Swedish scientist Berzelius for analysis. In turn, Berzelius turned the mineral over to his assistant, 25-year-old Johann Arfwedson, and requested a complete physical and chemical analysis.

In routine fashion, Arfwedson prepared his report. The physical properties were easily obtainable, but when he began a qualitative analysis, he ran into trouble. He found petalite to contain 78.2% silica, 17.8% alumina and a trace of lime. His figures totaled 96.0%. What happened to the other 4.0%? After Arfwedson tried every chemical test he knew, he decided that a previously unknown substance must be here. His search ended with a new element which was called "lithion" from the Greek *lithos* (stone).

It has been many years since the young Swedish chemist discovered our lightest metal, lithium, but with the demands of space technology the importance of this metal cannot be considered lightly. In the Oct 12 issue, an article will discuss the advantages of adding lithium to magnesium for structures 25% lighter than magnesium alone.

The Tower Philadelphia Almost Had

It seems that whenever a great historical event occurs or an important person dies, someone starts a campaign to erect a monument. Washington, DC, for example, is literally adorned with monuments, statutes and towers of all sorts and dimensions. The latest is a bell tower erected last year in memory of the late Senator Robert Taft. In the past, monuments usually took the form of a tower, but were not always erected in memory of an individual. An important military victory might be cause enough for a tower and an international fair always provided an excuse to build some sort of a monument.

For America's Centennial Exhibition of 1876 there was talk of bringing the French bridge-builder, Alexandre Eiffel, to Philadelphia—to design and erect a 1000-ft structure. Much discussion and confusion followed. Committees were formed, generating even more talk. The idea was finally rejected, leaving the centennial without an appropriate monument. To save the day, another Frenchman, Frederic Bartholdi, announced that a portion of his Statue of Liberty would be ready. So, Americans first saw Miss Liberty's famous torch in Philadelphia. Ten years later, the finished monument appeared in the Hudson River. As for Eiffel—the tower that would have been constructed in Philadelphia in 1876 was built in France for the Paris International Exposition of 1889 and is today, the most famous tower in the world. There are over 12,000 structural members, each requiring a special drawing. Of the 2½ million rivets in the Eiffel Tower, 800,000 were set by hand. The tower took only 26 months to construct, and Eiffel's engineering drawings were so good, no correction was needed once the tower construction began.

The building of towers is no longer restricted to famous battles, people or fairs. Now every missile launched moonward leaves behind a tower that in itself is an engineering marvel. One of the latest is the 15-story portable missile tower described on page 57.

Georg Ohm—Electrical Pioneer

All advances in modern electrical design can be traced back to a few stubborn pioneers who realized there must be a reason behind the mysterious behavior of electricity. Gilbert wrote a book on magnets, and soon Volta and Galvani published material on the new electrical science. Franklin and Gauss followed with advanced theories on electricity and Henry and Faraday worked on electromagnetic induction. Ohm was another pioneer, whose work on the characteristics of a galvanic circuit led to the law for determining the flow of an electric current within a conductor (p 61).

Georg Simon Ohm was born in Germany toward close of the 18th century. His father was a struggling locksmith, so young Ohm had to work his way through school. He was a brilliant scholar and graduation was quickly followed by a teaching job at the Univ of Cologne. While teaching, he became fascinated by the work of Galvani and obtained a leave of absence in order to pursue some ideas of his own. In 1826, Ohm began working in his brother's home, and for the next year, diligently applied himself to preparing a book—in it, he considered the term "electromotive force" as the force driving a current through a conductor, and thought of current and resistance much in the same sense we do today.

The importance of Ohm's published works was completely ignored. Worse, criticism of his book caused him to lose his job at the university. It took 20 years before the scientific world realized the importance of his pioneering. Now not only is the law Ohm first described named after him, but he has the unique distinction of having the electrical conductivity of a conductor, a "mho," also named after him. Mho is simply Ohm spelled backwards. This inversion makes sense because conductivity is the reciprocal of resistivity.

—Benedict A Leerburger Jr

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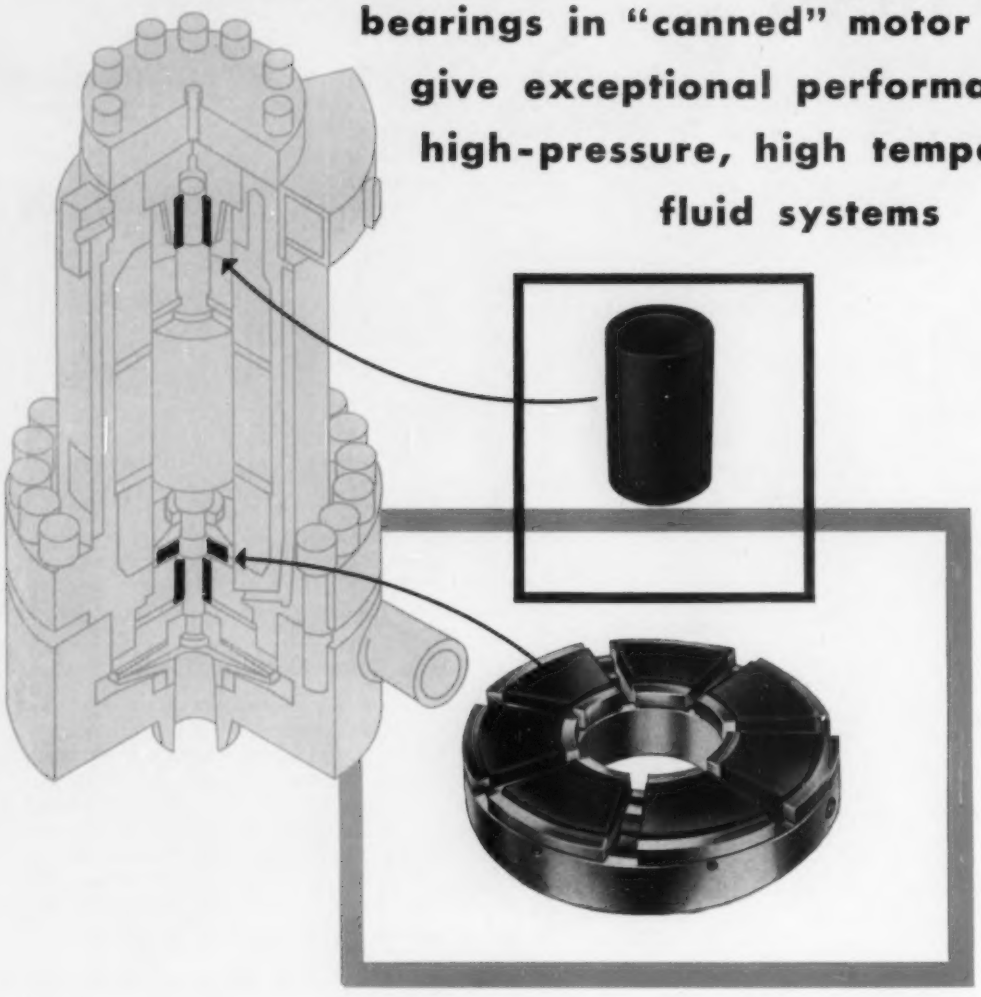
bearings in "canned" motor pumps give exceptional performance in high-pressure, high temperature fluid systems



Special hermetically sealed motor-pumps, known also as "canned" motor pumps, were developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

The thrust bearing utilized in the "canned" motor pump is a self-equalizing, water-lubricated, pivoted-pad bearing with inserted GRAPHITAR bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only . . . in the case of pumps used in nuclear reactors, only radioactive hot water is employed as lubrication.

GRAPHITAR is utilized extensively in tough applications because of its many unusual properties. It is non-metallic, resists chemical attack, has self-lubricating properties, a low coefficient of friction, is mechanically strong, hard as steel and lighter than magnesium. GRAPHITAR will not warp and shows no expansion or contraction in extreme temperature changes.

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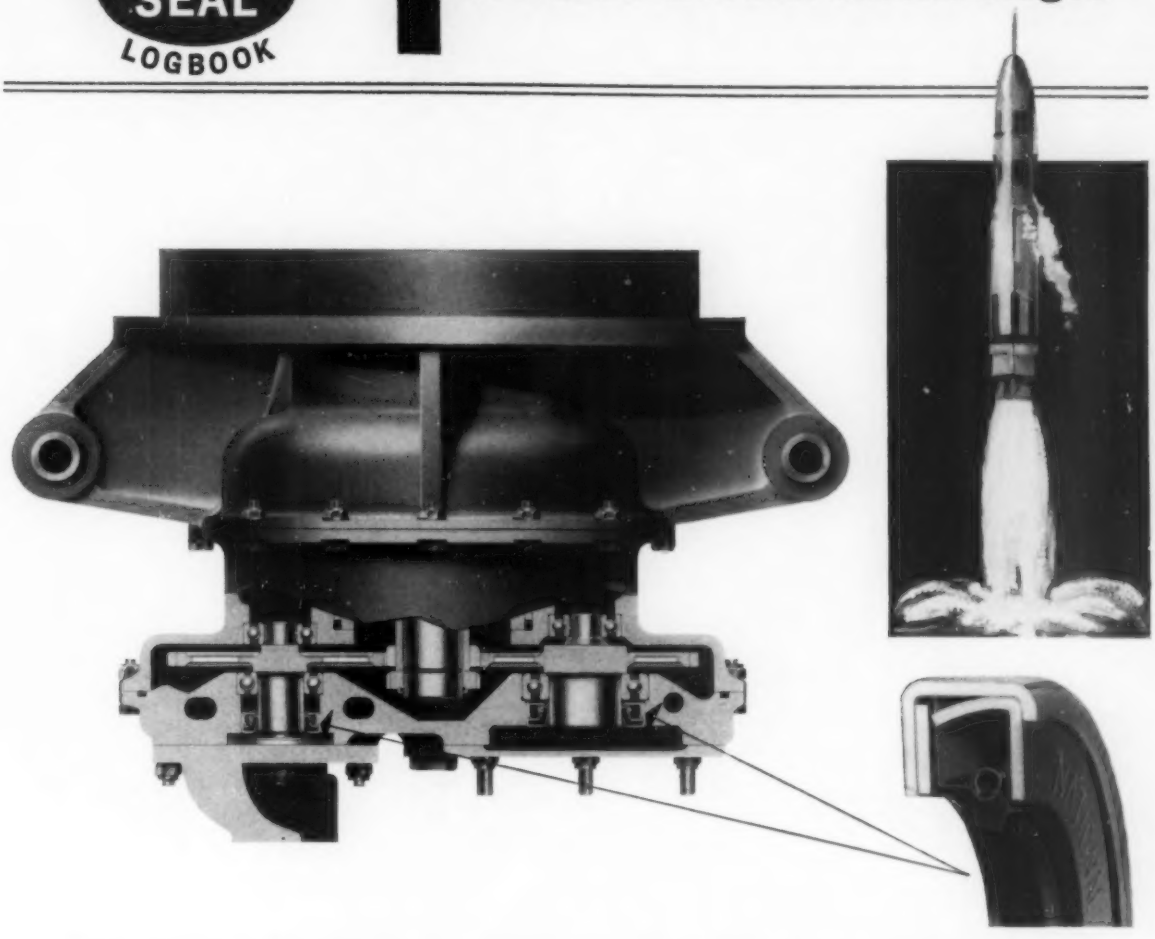

Aerojet-General solves sealing problem on shafts accelerating 0 to 3,800 rpm in 1 second

Zero to 3,800 rpm in 1 second, on 1" band 1½" shafts. Synthetic-base lubricant to retain. Magnesium housing. Operating temperatures —65° F to 300° F. Utmost dependability an absolute essential. These are typical of operating conditions in the turbopump gear boxes of the first and second stages of the Titan missile.

Aerojet-General and National Seal engineers answered the shaft sealing problem on the 3,800 rpm shafts by adapting a standard-design National Oil Seal. The seal's outer case is aluminum for light weight and to match closely the coefficient of expansion of the magnesium housing. The tensioning spring is stainless steel, unaffected by synthetic lubricants. The single-lip sealing member is a specially compounded Buna N synthetic rubber, specifically designed for use with the synthetic-base lubricant.

National offers over 2,500 different standard design oil seals; provides special seals for special applications. For complete information or sealing engineering assistance, call your National Applications Engineer. He's listed under Oil Seals, in the Yellow Pages.

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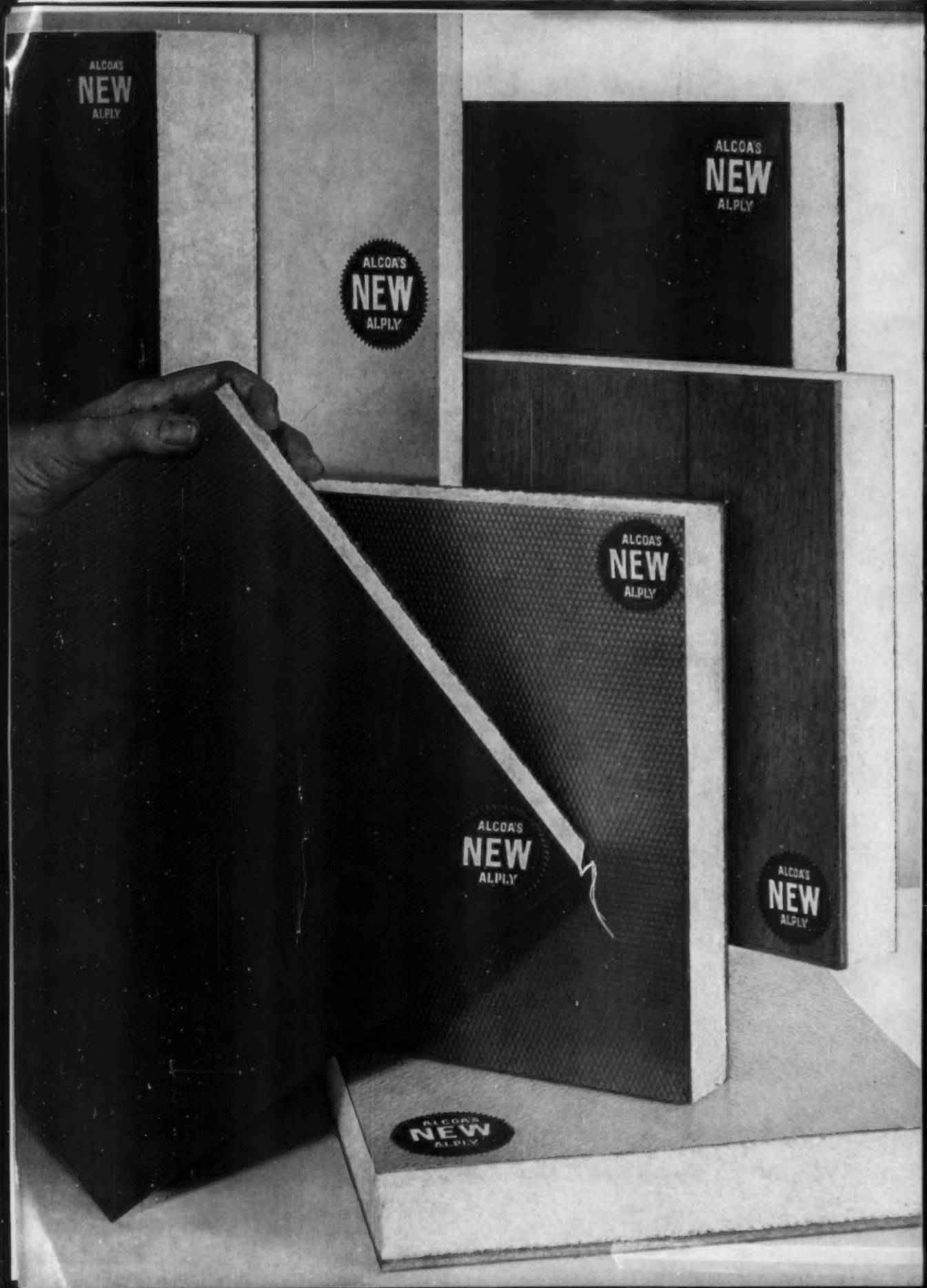
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Strength Properties—Complete tables of safe values, including bearing stresses and edge compressive load, safe bending moment and transverse shear, deflection and effect of elevated temperatures.

Surface Finishes—Illustrations and descriptions of the wide range of finishes available for interior and exterior uses of Alply panels.

Weather-Resistant Properties — Figures and tables showing the remarkable weather resistance of aluminum facings.

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Design horizons are broader than ever since the introduction of Alcoa® Alply insulating panels. Their combination of light weight, strength, stiffness and insulating efficiency—PLUS the corrosion resistance and breadth of colors and finishes common to aluminum—means that imagination imposes the only limits on their use. We produce Alply panel in normal widths up to 48 in. . . . expand its rigid foamed plastic core to provide thicknesses up to 6 in. . . . turn out lengths as long as shipping facilities permit. You can specify aluminum for both facing sheets or substitute plywood, plasterboard, gypsum board or hardboard on one side. Tested procedures for cutting, forming and joining make fabrication simple and economical.

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Do low-cost beauty and durability suggest a novel architectural use? Can you capitalize on the opportunity for fast, inexpensive production? Plan a better mobile home? Build a refrigerator or cold room for less money? Redesign a "reefer" car or truck for lighter demands on cooling equipment?

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We want to put an actual sample of Alply in your hands so that you can measure its potential against your requirements. We would also like to send you our new, 24-page fact book called *This Is Alply*. You, in turn, can help us appraise your needs if you will tell us about your plans when you fill out the accompanying card for mailing.

Your Guide to the Best in Aluminum Value

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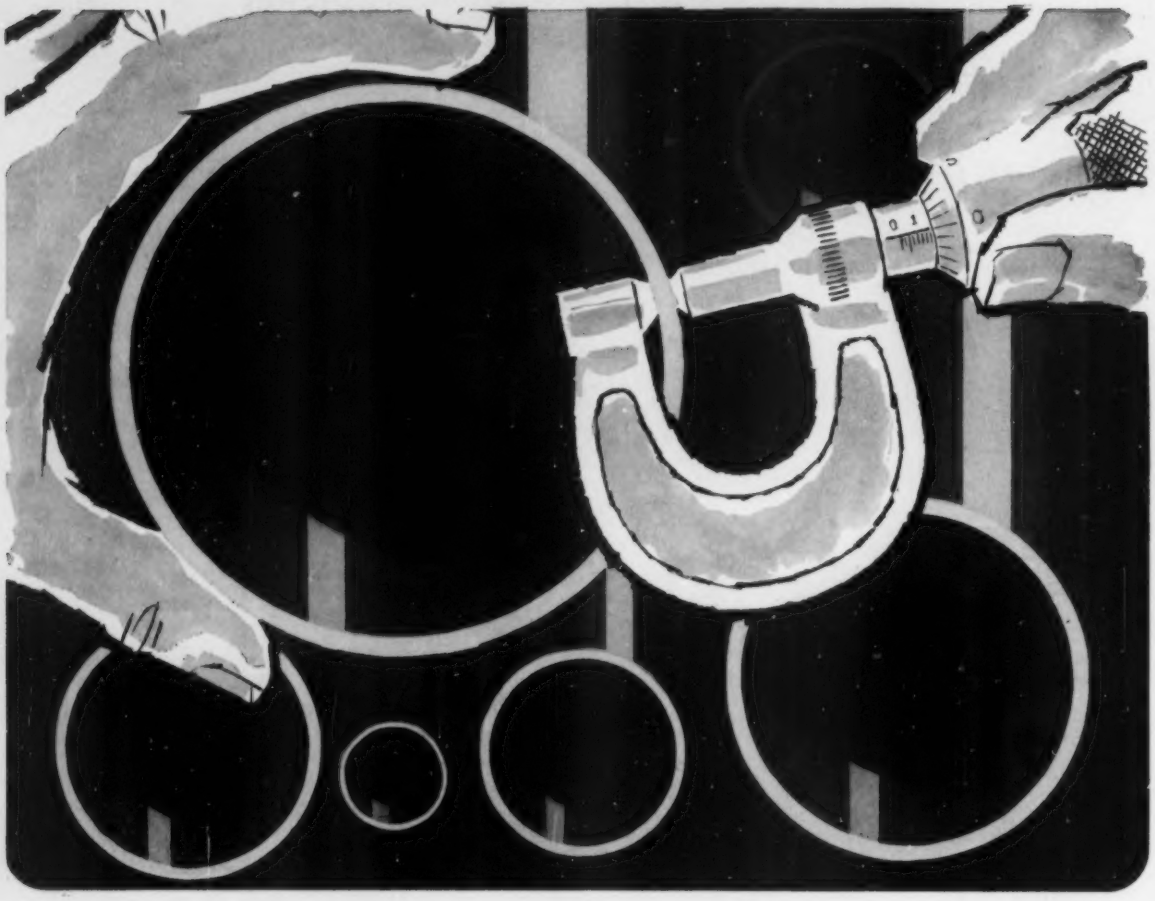

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Allegheny Stainless Tubing ranges from 3/16" OD to 3½" OD with wall thickness from .013" to .375". Typical of the specials A-L can make are 2½" OD—.032" wall thickness, 3" OD—.042" wall thickness and 3½" OD—.058" wall thickness. All sizes with true circularity, no dents or handling marks.

Stainless seamless tubing is made in all stainless grades including 309, 317, 318, 310, 416 and 446—normally difficult to obtain. For special high-temperature applications, A-L produces tubing in high-strength alloys such as A-286, and in vacuum melted steels and alloys. Also in custom analyses such as low cobalt (.01-.05) grades and with boron additions to standard grades.

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Allegheny Ludlum Tubing is available in small orders in random or cut lengths. Standard grades in stock throughout the country.

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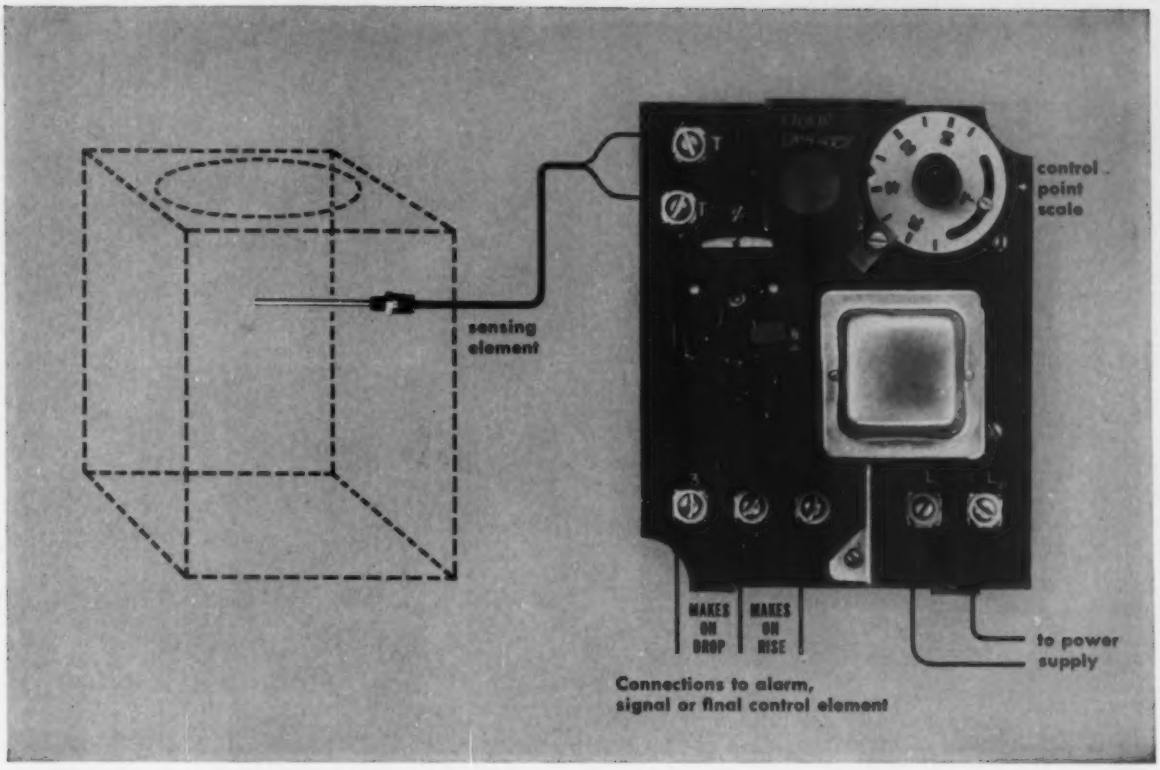

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VERSA-TRAN is an exciting new development in low-cost controls—an entirely different kind of amplifier relay that works with specially designed sensors to control temperature with the accuracy usually found only in more complex instruments.

VERSA-TRAN relays are fully transistorized, vibration resistant, and designed for long, dependable service in even the most demanding applications. They control liquid or air temperatures in overlapping ranges from –60° to 500° F, and surface temperatures from –60° to 200° F.

Wiring between the relay and the sensor can be ordinary 18 gauge, 2-conductor cable. The relay is available for flush mounting, surface mounting, or for mounting in most electrical enclosures. It has been accepted for UL listing. VERSA-TRAN gives you flexibility and sensitivity at surprisingly low cost . . . is already solving many difficult control problems.

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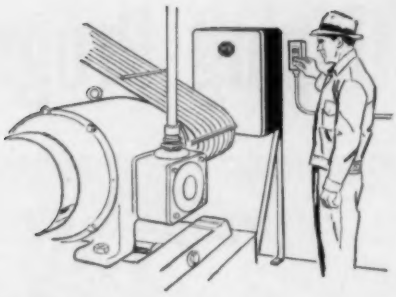
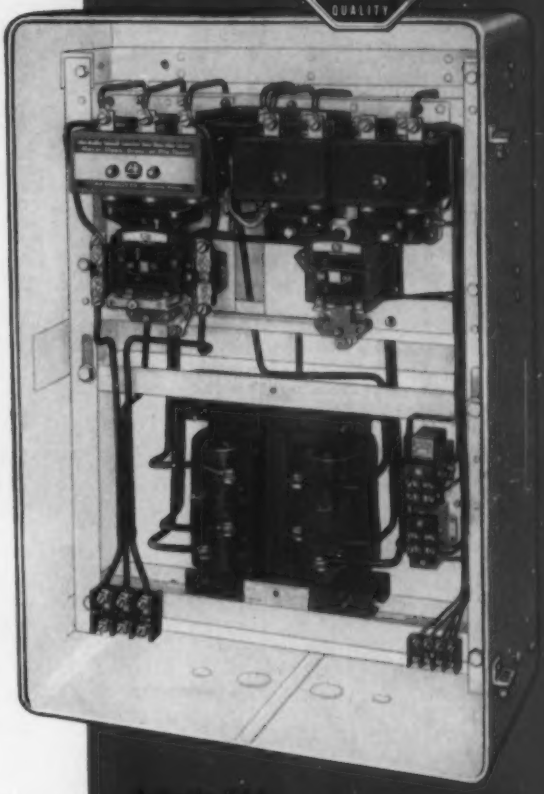


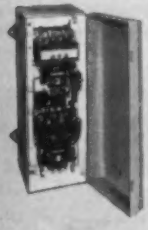
WHEN REDUCED VOLTAGE STARTING IS A MUST

Only Allen-Bradley can provide all the answers

The Allen-Bradley line of reduced voltage starters makes possible a selection of the best starter, not only to meet the power company's requirements but also to provide the best starting conditions for the motor and the "load" that it drives.

The simple solenoid contactors in A-B reduced voltage starters have only ONE moving part—assuring millions of trouble free operations. And their double break, silver alloy contacts never need costly maintenance. Accurate, reliable overload relays protect motors against burnouts. Write for Publication 6008.



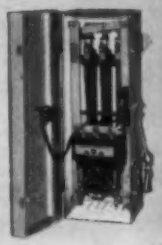


Bulletin 740

Graphite disc resistors are automatically inserted in series with the squirrel cage motor at starting, and they are automatically cut out after a predetermined time. Turning a single screw on the starter frame adjusts the compression resistors exactly to motor and load conditions for velvet smooth acceleration. Ratings to 200 hp, 220-440-550 v.

Bulletin 640

Where remote control is not needed, these graphite compression disc resistor starters provide stepless acceleration of squirrel cage motors. Operated by hand lever, the smooth starting of the motor is under the control of the operator. No-voltage and dependable overload protection is provided. Ratings to 200 hp, 220-440-550 v.



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ALLEN-BRADLEY

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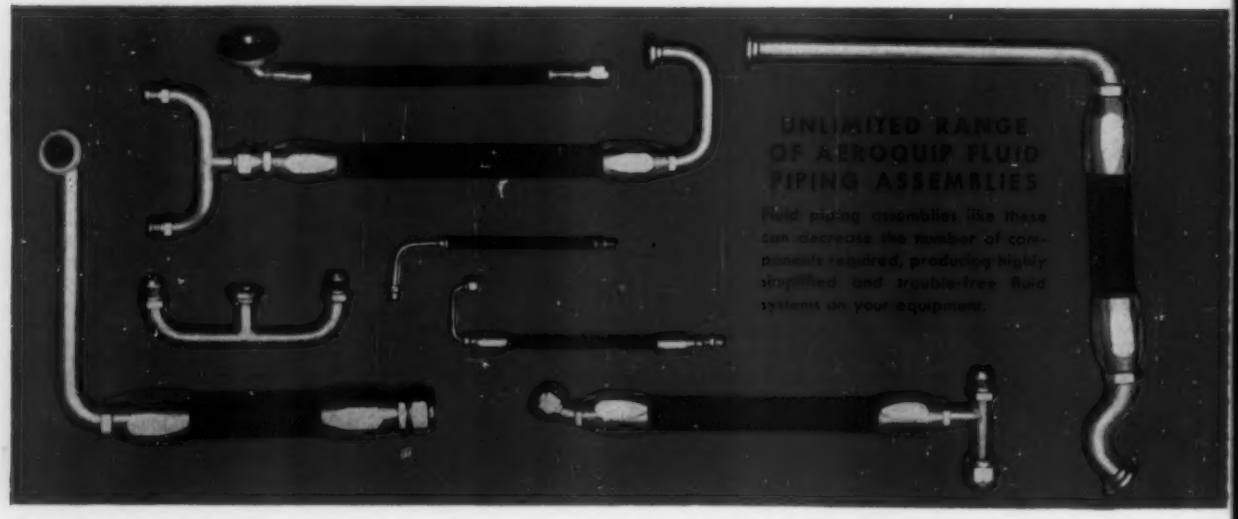
Quality Motor Control

How Aeroquip's Fluid Piping Program

Aeroquip sales engineers direct the service teams in the field. One is shown here discussing a problem with the manufacturer's representative. The Aeroquip sales engineer has followed equipment development and is thoroughly familiar with the fluid piping system.

Aeroquip service engineers are trained trouble-shooters who can test a fluid system and locate quickly the source of a problem.

The Aeroquip designed and built Hydrauliscope is being used by a service engineer to analyze fluid systems in operation. It presents electronic data that often shows where unexpected peak pressures result under field conditions.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PIPING ASSEMBLIES
Fluid piping assemblies like these can decrease the number of components required, producing highly simplified and trouble-free fluid systems on your equipment.

Helps You Solve Field Service Problems

SKILLED AEROQUIP FIELD SERVICE SPECIALISTS ARE AVAILABLE TO EQUIPMENT MANUFACTURERS WHO UTILIZE AEROQUIP'S FULL RANGE OF FLUID PIPING SERVICES

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- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

Sound engineering plus experience gained in working with your engineering and production people in the design, prototype and assembly line stages, enables us to accept full responsibility for the performance of Aeroquip products on your equipment. Experienced Aeroquip field service engineers are available to you to assist in providing *after sale* service when needed.

This field service is one of the most unusual advantages offered in Aeroquip's fluid piping program. It is one of the final steps in a complete fluid piping program which includes assistance in original design, prototype development, production planning and even includes extensive assistance in service parts programming.

Start, today, to simplify your fluid piping problems. Mail the coupon below for complete information.

Check list of hose installations and thorough inspection of the entire fluid piping system is routine for the Aeroquip field service team.

Soundly engineered equipment backed by quality manufacture assures the user maximum performance in the field. Aeroquip is proud of its association with many leading equipment producers.

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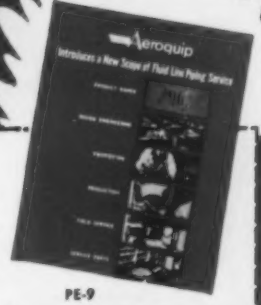

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Aeroquip Corporation, Jackson, Michigan

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- ☐ Please have an Aeroquip Sales Engineer call on me to discuss this service.

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Vari-Speed Motodrives mean versatility in variable speed

101 *different standard assemblies*

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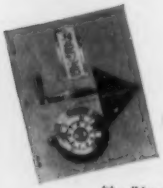
32 *different standard flange assemblies*

REEVES has the variable speed answer for virtually *any* installation . . . with *standard* Motodrive units. This rugged, compact power package is available from ¼ to 20 hp., 1.7 to 4660 rpm., in 2:1 thru 10:1 speed variations. Single, double and triple stage reducers provide gear ratios from 1.17 to 195:1. Other Motodrive units up to 40 hp.

There's space-saving versatility, too . . . REEVES Motodrives come in two styles: "C" flow, as illustrated, and "Z" flow, where motor is on opposite side of the case from the output shaft.

Extra precision . . . a complete line of controls, ie. AIRtrol (a pneumatic positioner), electric remote control, mechanical controls, magnetic brakes and tachometers. **Extra versatility** . . . to meet specific needs, REEVES offers a full array of modifications, ie. special motors, shaft extensions and scoop mountings for foot-mounted motors.



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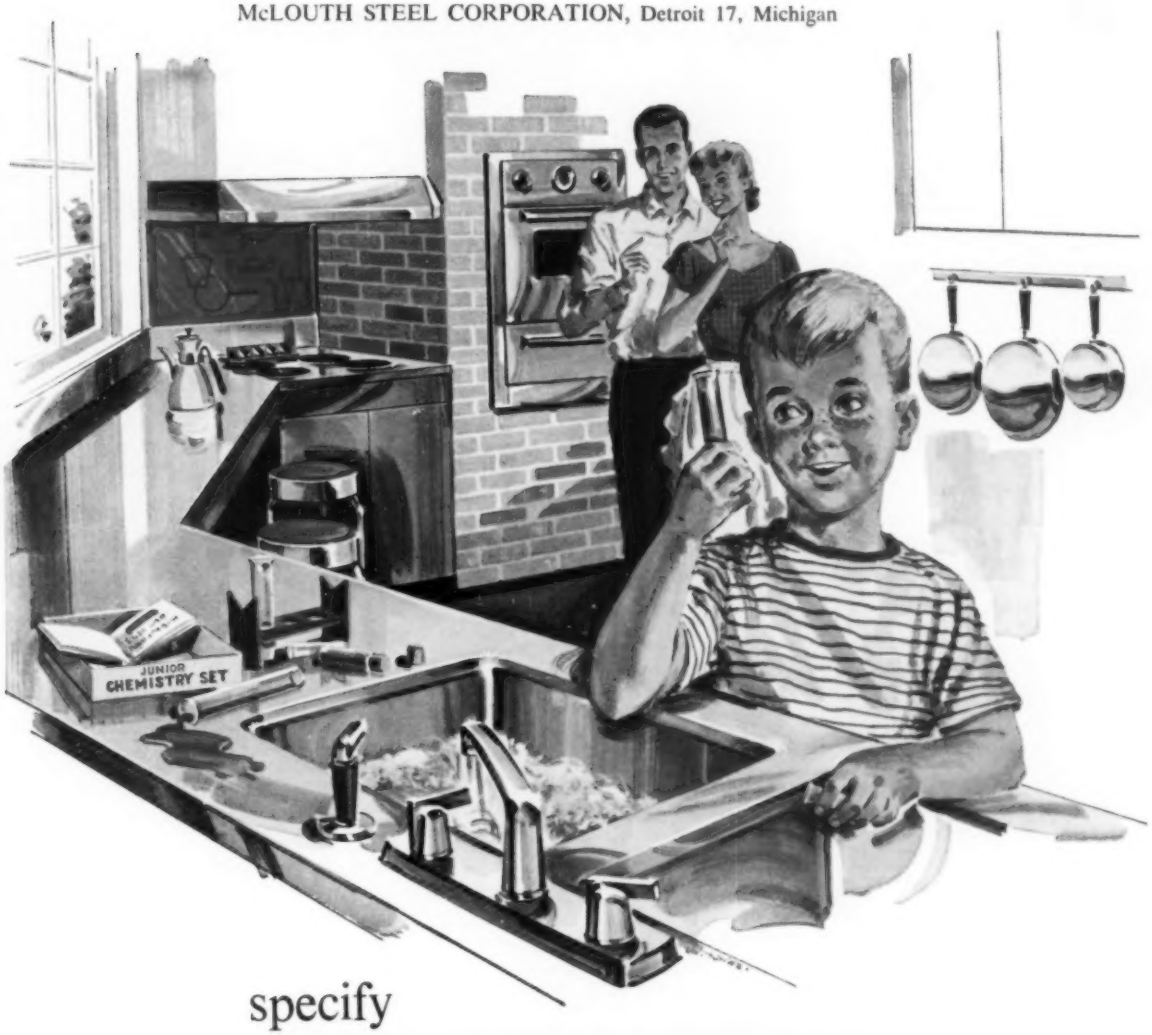

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RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

The strength of nuts

With a hard, heat treated nut, ability to plastically adjust and distribute load over many threads diminishes. High loads tend to concentrate on first thread severely enough to cause stripping . . . or fracture of first thread, which causes locking. Nut then cannot increase tension in bolt.

Untreated nuts are strong enough for most needs, and don't pose this problem.

A CAUSE OF STRIPPING

Upon tightening, a nut both compresses and dilates. Dilation can be overcome by wall thickness only, not by added height or heat treatment.

Dilation is important since a reduction in area of bolt under tension accompanies it. Threads pull away from each other, from their stronger base to weaker tips. The shallowness of *fine* threads can cause progressive shear.

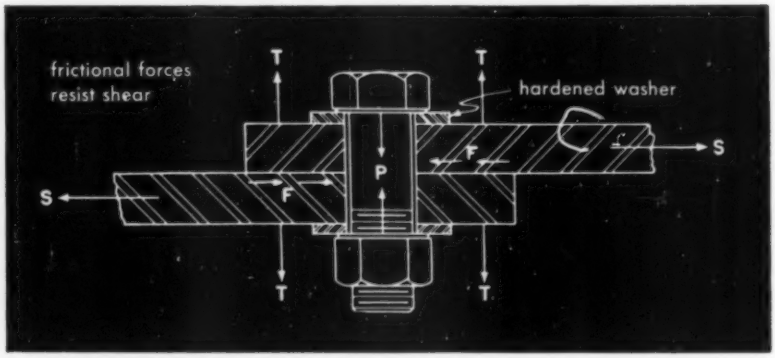
That's why High Nuts (with fine threads) are no answer where "Heavy" Nuts (with coarse threads) are.

WRENCHING STRESS HIGHEST

Rotation of nut produces both tension and torsion in bolt. The force applying this combined stress is about 20% greater than the load which must be sustained when rotation stops.

Thus . . . if a nut hasn't failed in wrenching, it can still withstand at least 20% more direct pull than it sustained during the tightening.

Why high strength bolts make superior joint for dynamic loads



Washers prevent crushing under head and nut with consequent grip relaxation.

While fasteners must be strong enough to carry the calculated loads, what makes a *joint* truly strong is the *residual tension* after wrenching.

NO SLIP OR SEPARATION

Consider the simple lap joint in sketch. Practically rigid, this joint is subjected only to: (1) external tension forces "T" tending to separate the plates against bolt clamping force "P"; (2) shear forces "S" tending to make plates slip against friction resistance "F".

"F" increases when "P" does. With enough clamping force applied, shear loads transfer from one plate to the other without slippage. And when clamping force always exceeds tensile forces, plates obviously *cannot* separate. There can be no further stretch on bolt. Its load stays static at preload "P", even when external loads are dynamic.

UNIFORM CONTROL OF PERFORMANCE

RB&W high strength bolts allow a high magnitude of clamping force to be applied . . . and *uniformly* so. Materials conform to ASTM specifications. Applying known torques to nut produces uniform bolt tensions. Riveting by contrast, depends on difficult-to-control variables.

MORE STRENGTH OVERALL

For shear-resistance, riveted joints offer only the actual rivet shear strength. Don't count too much on friction even though rivets exert some grip as they cool. Compare: a 1-inch bolt tightens to a tension of 42,000 lbs; a 1-inch rivet develops 22,000 lbs at best.

The higher residual tension does more than make a joint much stronger in shear and in tension. It also protects the bolt against fatigue caused by stress-reversing cycles such as vibration; keeps the bolt from loosening, too.

All this explains why, under heavy dynamic loads, rivets can loosen, elongate holes, often fail, requiring difficult replacement; but high strength bolts stand up. They can keep connections permanently tight on vibrating machinery, heavy duty conveyors, and transportation equipment.

Talk it over with an RB&W fastener expert. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

RB&W high strength bolts are from selected grade of medium carbon steel with proper combination of ductility and tensile strength; conform to ASTM A325.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

DEVELOPMENTS TO WATCH...

High-purity tantalum at less than $20 a lb . . .

. . . is promised by a new process developed by Aries Associates. It's a new technique that bypasses the conventional fluoride reduction and the conventional purification processes and produces a high-purity halide that can be directly reduced by electrolysis or a Kroll-type system. The resulting material, says Aries, is even purer than that now used for electronic and alloying applications—and very much lower in cost.

First plant to use the process has been built in Japan; but plans are now being made to put it into production in both the US and Europe. Furthermore, Aries believes it will be applicable to other refractory metals and should make it possible to achieve substantial price reductions for these materials as well.

New compounds sensitive to ultraviolet light . . .

. . . show promise for detecting and indicating devices. Such compounds are surprisingly rare and, aside from silver salts, relatively unknown. But several recently prepared complex sulfates of cobalt, chromium and related metals do show potentially useful reversible color changes. One, undergoes a phototropic (reversible) color change after original short-term exposure to ultraviolet light and also after prolonged exposure followed by heating. Two others, recently prepared at the GM Research Labs, do exhibit a definite color change after exposure followed by gentle heating. However, as S. E. Beacom of GM told an ACS meeting earlier this month (*PE*—Sep 14, p 36), in one, the color change is not reversible; and neither will stand elevated (above 250 F) temperatures after exposure. Indeed, both explode at 250 to 300 F. Further studies are planned to find out why these effects occur and how to put them to work.

Superior dielectric liquids can be formulated . . .

. . . by taking advantage of new knowledge of molecular structure, Naval Research Lab scientists say. They've prepared fluorinated compounds with dielectric constants as high as 8 that show "unusual oxidation and thermal stability, resistance to hydrolysis, and inertness toward metals"; and they believe the dielectric constant can be boosted another 50% at least. Their present goal is a capacitor impregnant that will permit stable operation over the full range from −85 F to 400 F. They also hope to reduce component size and increase service life.

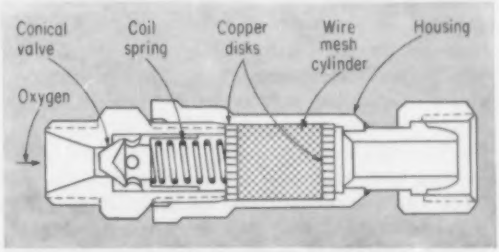
A report on 5 fluoroesters so far prepared, and on the basic chemical investigation, is being drawn up and will be available through OTS, Dept of Commerce, Washington 25, DC, as PB 151797. No release date has been set, but the report is expected to run between 50 and 60 pages and will be priced at about $1.50.

Safety valve for cutting tools that use oxygen . . .

. . . features a delay system that absorbs heat and slows down the passage of flame until the valve can close and shut off the gas supply.

Normally, oxygen enters at the left (see diagram), its pressure being sufficient to compress the spring and keep the valve open. It then flows through the copper disks and mesh cylinder to the working end of the valve (right). But if an explosion occurs, its backward pressure wave compresses the spring and presses the valve against its seat, shutting off the flow of oxygen.

According to Soviet engineers who designed the device, the wire mesh "hinders the advance of the flame sufficiently to permit the safe and sure closing of the valve; and the heat generated by the backstroke is completely absorbed and dissipated by the nonferrous metals of the valve mechanism." Minimum dia of the oxygen passage is about ¼ in., and maximum pressure a little over 200 psi.



Valve delay system consists of bronze spring, copper disks, and wire mesh cylinder.

DEVELOPMENTS TO WATCH...

To study low-energy spark discharges . . .

. . . Bureau of Mines researchers have developed auxiliary equipment for use with a commercial dual-channel oscillograph to permit observation of capacitance-discharge sparks in the 10 millimicrosec range.

By adding delay lines, a voltage divider consisting of a large capacitor in series with the main energy-storage capacitor, and a coaxial relay that makes it possible to use the current channel to calibrate the voltage channel, they've been able to achieve sweep rates on the order of 20 in./millisec—a 4-fold improvement over the unit as received—and a frequency band width of better than 200 mc.

An engineering report, with circuit diagrams, has been prepared and may be obtained without charge from the Publications Section, 4800 Forbes St, Pittsburgh 13, Penna.

Epoxy resins with greater thermal stability . . .

. . . are being developed at Melpar Inc.

First step in the program was to find the most revealing test for heat resistance. Of those investigated — Thermal Gravimetric Analysis, Differential Thermal Analysis and Heat of Distortion measurement—the first seems most indicative because, say Melpar engineers, the curves so obtained share a well-defined "knee" at the point where disruptive volatilization first becomes rapid, thus enabling clearer interpretation of degradation temperature.

Second step in the program, still in process, is development of new intermediates from which epoxy resins may be prepared. Several compounds that yield water-insoluble foams have already been found; and Melpar hopes new intermediates will produce resins with a new range of thermal stability.

British standard for flameproof electric motors . . .

. . . now includes a new insulation class, Class E, that is not recognized in the US. It is based on an ambient temperature not exceeding 104 F, and splits the difference between Classes A and B almost evenly all along the line. (For example, for stator windings rated at 1000 v and below, the allowable temperature rise is 131 F for Class A; 167 for Class B; 149 F for Class E.)

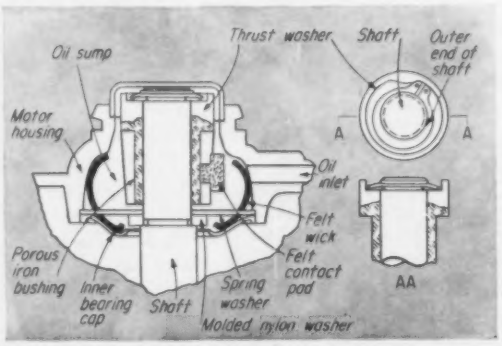
The new British Standard also includes Class F for the first time. This is recognized in the US. But its value is being questioned by users as well as producers of silicone insulation, in view of the growing acceptance of Class H materials in this country, and the general trend toward higher temperature insulation.

(Note: a convenient source in this country for a chart of the temperature specifications for all 5 classes is Dow Corning Corp, Midland, Mich.)

New bearing assembly for vertically mounted motors . . .

. . . is designed for use where higher temperatures frequently cause trouble. It's self-lubricated (by means of a porous iron bushing and felt contact pad) from an oil sump provided within the housing.

As the bearing rotates, felt contact pads feed oil to a porous iron bushing which distributes it to the thrust washer as well as to the journal of the shaft. The washer, of porous bronze, in turn throws the lubricant out centrifugally into the well of the housing from which it passes down again to the main sump (see diagram). Lubricant is also thrown from the bottom of the journal by the molded nylon washer and picked up by the felt wicks in contact with the inner bearing cap. This oil, too, returns to the main sump. Newman Industries Ltd, Bristol, England, has patented the device; will offer motors with the new bearing at a nominal figure—about 2% —above standard machine price. —ARG



Self-lubricated bearing is designed to feed oil from wool-packed sump, built into motor housing, to rotating shaft. It's expected to reduce high-load bearing failure in such applications as hot-water circulating pumps.

Photo Typesetting Units, Wrap-around Plates Pace Advances in Printing Equipment

NEW YORK—For the first time in a decade, manufacturers of printing equipment have assembled to exhibit the latest technical advances in their art. The show at the Coliseum here, sponsored by National Graphics Arts Expositions Inc, evidenced industry trends toward bigger, faster, more versatile presses, more rotary and offset presses, and more color printing.

Of considerable technological interest was the array of the so-called cold type or photo typesetting systems. At the last show in 1950 only one such unit was shown; this year offers five—by Photon Inc, Mergenthaler Linotype Co, Harris Intertype Corp, American Typefounders Inc, and Langston Industries Inc.

Photon's system—result of nearly 14 years of R & D—differs from competing models in that it employs a mechanical memory unit instead of punched tape to store copy for photographing. The system has a typewriter keyboard on which this copy is typed, then transmitted to the memory unit.

Elsewhere in the console a matrix disk with 16 type styles rotates at 10 rev a sec. When a line of type is correct and ready for photographing, a stroboscopic flash, synchronized with the matrix disk, illuminates type on the disk as selected at the keyboard. The flash operates at 4 millionths sec and optically stops the disk for exposure. Characters on the disk are exposed through lenses to produce print ranging from 5 to 72 points in size (this copy in PRODUCT ENGINEERING is 9 points; the headline is 24 point). There are 12 lens sizes. The print photographed is shown as a positive image on photographic film or paper. At present most units in use are operated by newspapers for display advertising.

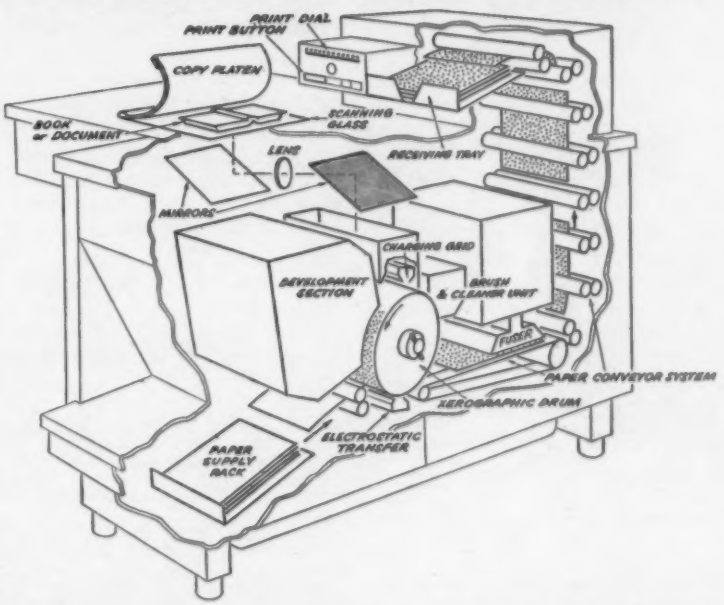
TAPE-OPERATED SYSTEMS

Typical of the tape-operated units is the American Type Founders Typesetter. It has two components: a conventional typewriter keyboard for producing the perforated tape; a photographic unit for converting the taped information to film or photographic paper. A spinning disk in the unit is illuminated to produce the image called for on the tape. A separate disk is used for each type style and size.

Harris Intertype Corp's contender —the Fotosetter—includes one model especially equipped for producing engineering diagrams. Designed for reproducing electronic and electrical circuit diagrams, Fotosetter produces transparencies for the offset-plate maker. The engineer or draftsman roughly sketches symbols, nomenclature and other information on a special form with a ¼-in. grid pattern. The Fotosetter operator types out this information line by line on the machine's keyboard. The photographic unit has a special disk with electrical, electronic symbols and characters.

Wrap-around and photopolymer plates, and presses for using these one-piece letterpress printing plates, were also among pacesetting technical advances on display. Such plates sharply reduce time required to get presses ready. Harris Intertype demonstrated a new wrap-around rotary letter press. Key improvement here is a precision-cylinder mechanism that inks the entire plate in one revolution—ordinarily inking requires critical adjustment of rollers. Wrap-around plates were shown in zinc, magnesium, chrome-plated copper and Dupont's new photopolymer — Dycril. The Harris press was developed jointly by

Electro-photography Keeps Pace With Printing Progress

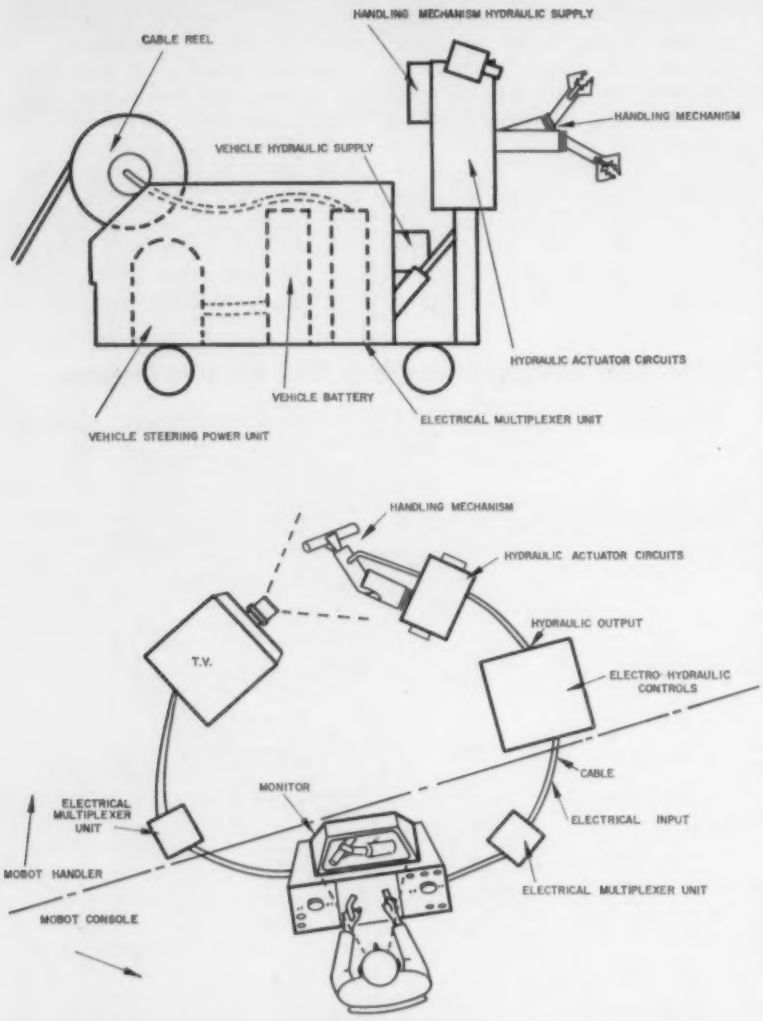


First fully automatic office copying machine, doubling also as a duplicating machine, is unveiled by Haloid Zerox Inc to be available commercially early in 1960. Requiring no sensitized or treated papers, nor exposure or developing adjustments, Zerox 914 Copier represents a design outgrowth of electrostatic printing principles. Operator need only place original document, magazine, or book over glass panel on copier desk, then dial for the required number of copies from 1 to 15; if more are needed, additional setting is required. It prints at a rate of 6 per min any number of photo-exact, curl-free, stacked copies. Prints may be made directly on ordinary white or colored paper, offset paper master material, card stock or vellum. Device will efficiently reproduce in black any colored printing.

the company's central research labs and the Marathon Div of American Can Co.

Technical development of the past 10 years in the printing industry may be dwarfed by those of the next decade, observers at the show predicted. This industry is drawing heavily on technologies of electronic and chemical firms to advance printing techniques. Such giants as RCA, IBM, Burroughs, Remington Rand, Eastman Kodak, Dupont, and Minnesota Mining and Manufacturing are cited as companies that have shown interest in printing techniques. ■

Machine Does Man's Job in Reactor



Mobot Mark I, as shown in top drawing, is a remote-controlled, mobile handling mechanism for radioactive areas. Developed by Hughes Aircraft Co, the unit will be used by Sandia Corp, direct contractor to the Atomic Energy Commission for phases of special weaponry. The handling-arm assembly, including wheels and appropriate controls, is the only part of the assembly that operates in the radioactive area. A cable extension on a reel connects the handling equipment to an operator's console located up to 200 ft from and out of sight of the radiation cell. Drawing below shows how operator can sit at console and feed it more than 100 commands through electronic "reins" while viewing the actions through Mobot's TV camera.

Transport Industry Takes to Aluminum

DETROIT—Aluminum will average some 60 lb per automobile in the 1960 models, up from around 52 lb for the current models, said David P. Reynolds, exec vice pres of Reynolds Metals Co. Greatest factor affecting the rise is the 100 lb of aluminum in the GM compact Corvair.

Reynolds noted that all segments of the transportation industry are turning to aluminum to reduce weight:

- Aircraft, being most sensitive to the weight problem, was first to make wide use of aluminum and other light metals.
- In the automotive industry, trucks and trailers are increasing their use of aluminum to increase payloads. Most recent development is the introduction of aluminum cabs.
- In passenger cars, Corvair's aluminum engine is only the first of a series. A number of other engines made mostly of aluminum have been developed, tested and refined, and are ready for introduction over the next couple of years. These include air-cooled and liquid-cooled engines. Aluminum diesel engines are already in production.
- In ships, aluminum is increasingly used for hatch covers, lifeboats, railings, and entire superstructures. A recently designed aluminum hull, certified by the government's Bureau of Ships, greatly increases the ship's payload.
- An order for 1200 aluminum freight cars was placed recently. These gondola and hopper cars will be money-makers because of their lower upkeep, longer life and larger payload. ■

British—Soviets Matching Fairs

LONDON—Contract for a British Trade Fair in Moscow in June 1961 and a Soviet Fair in London a month later is expected to be signed the end of this month.

The projects, negotiations for which began early last year, will be jointly sponsored by the Assoc of British Chambers of Commerce and the All-Union Chamber of Commerce of the USSR. ■

Banking's Common Language Makes Computers Practical

Within days of each other, Burroughs and General Electric announced data-processing equipment for banks. Using highly stylized characters known as the ABA (American Bankers Association) Common Machine Language, these processors sort, check, record, post and file checks and deposit slips at high speed. For example, the Burroughs sorter, left, handles 1500 checks/min; the GE sorter, right, handles 750 checks/min. Both units are fully transistorized and use tape for storage. Full machines are comprised of a document-handler or sorter, electronic computer, control console, and a printer or processor.

Congress Says Army, Navy Not Getting Their Share of R & D Money

WASHINGTON—The House Space Committee has suggested that the Army and Navy are being shortchanged. The committee advocated more funds for Navy research and development and asked the Administration to review its budgetary policies to determine whether more money for over-all Defense R & D could not be used.

The Committee said that if "more and better research would overburden the national budget, cuts should be made in areas less vital to basic US security." The Committee offered this advice in a report summarizing the findings of 4 subcommittees which looked into what the armed services are doing in basic scientific and astronautic research. The full committee endorsed the subcommittee recommendations.

CONSTRUCTIVE CRITICISM

These included, among other things, a recommendation that Navy research and development funds be raised to 10% of the total Navy budget, or approximately $150 million a year.

A subcommittee headed by Rep Anfuso (D-NY), which looked into the Navy phase of the inquiry, said R & D funds average 8½% of the total Navy budget this year. Comparable spending by the Air Force and Army is 10% or more, the subcommittee said. The Navy budget for basic and supporting research, the report said, is "becoming relatively lower, year by year."

Another subcommittee, headed by Rep Teague (D-Tex), which looked into the Army program, said "budgetwise, the Army Research and Development program is, at present, just barely getting by." The subcommittee cited closed-door testimony by Lt Gen Arthur G. Trudeau, chief of Army Research and Development operations.

"It is significant," the investigators said, "that Gen Trudeau feels Army is not prosecuting more than half of the possible research areas which might be of genuine utility."

The subcommittee called it significant also that Maj Gen William W. Dick, Jr, director of Army Special Weapons, "admitted that budget conditions imposed upon him for the coming year are 'considerably tighter' than they have been in the past."

MANPOWER-MINDED COMMITTEE

Another subcommittee, which looked into Air Force research, offered no significant recommendations beyond suggesting that steps be taken to reduce the loss of scientific personnel who leave the Air Force for better paying jobs in private industry.

A fourth subcommittee, which checked on the Advanced Research Projects Agency, the Pentagon's Space Agency, submitted no findings or conclusions. ■

Statistics Cut Costs, Time of R & D

ANN ARBOR, MICH—Statistical methods used in the planning of research experiments reduce costs and cut research time, G. W. McElrath recently told a meeting of designers, researchers and industrial managers.

McElrath, Industrial Engineering Dept head at the Univ of Minnesota, explained that the purpose of most research efforts is to whittle down the range of "experimental error" or chance variation, by assigning part of the total variation to recognizable causes, and determining the range of variation for each cause.

The number of factors to be investigated can be determined in advance. Then statistical analysis can be used to plan the minimum number of types of tests to be performed in order to obtain results of a desired reliability level. ■

New High-purity Alumina Ceramic Better Than Sapphire Gem Stones

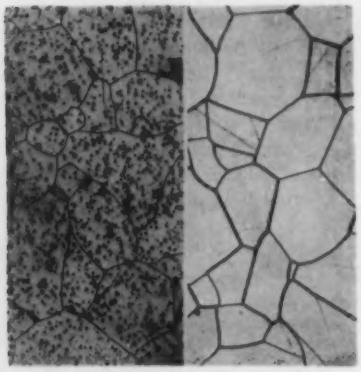
SCHENECTADY, NY—A polycrystalline made from powdered aluminum oxide ceramic that readily transmits light, that can withstand much higher temperatures than most ceramics now in use, and that can be pressed into any shape desired has been developed by General Electric Co. No other material combines translucence with the degree of strength, heat resistance, and ease of fabrication, offered by Lucalox, GE says.

Closely related to sapphire and ruby gem stones, which are single-crystal aluminum oxide, GE's polycrystalline form of the same compound is reported superior to these gems in ability to withstand high temperatures without deforming. It has the composition of a ceramic, the structure of a metal, and a light-transmitting ability approaching that of glass, according to Dr Guy Suits, GE vice-pres and director of research.

Because of the elimination of the small or "bubble pores," normally found in ceramic materials, it is possible to read through a sheet of Lucalox when it is laid flat upon a piece of paper. At greater distances it appears translucent, resembling frosted glass. At least 90% of the light in the visible spectrum is transmitted through the new ceramic.

PHYSICAL PROPERTIES OF LUCALOX

Property	Values
Optical (visible and infrared)	
Total light transmission, %	At least 90
Thermal	
Conductivity, cal/sec-cm-°C	0.076
Expansion, in./in.-°C (25–1000 C)	8.6×10^{-6}
Mechanical	
Transverse Rupture Strength, psi	50,000
Hardness, VPN	1660 to 1930
Electrical	
Resistivity at 500 C, ohm-cm	2×10^{12}
Dielectric Strength, v/mil (20 mils thick)	1700
Dielectric Constant, K	9.85
Power Factor, tan δ	0.00003
Physical	
Density, g/cm³	3.98
Crystal Structure	Hexagonal-polycrystalline
Melting Point, C	2040



Lots of Lucalox . . .

Pores in conventional ceramic (dark spots in photomicrograph at left) scatter the light, making the material opaque. In the highly dense Lucalox, developed at the GE Research Laboratory (photomicrograph at right), pores are eliminated and the new material transmits at least 90% of the light in the visible spectrum. Scattering of light at grain boundaries (dark lines in both photos) prevents the new material from being completely transparent. Magnification in both photomicragraphs is 100X.

The basic material of Lucalox is fine-grain, high-purity alumina. This aluminum oxide is pressed at room temperature, then fired at temperatures that are higher than usual for ceramics. Its development resulted from an investigation of basic principles of the sintering process. Lucalox has a metal-like structure in that its crystals are bonded directly to one another, with neither pores nor glass matrix between them. Information gained from the study of this material may consequently be applied to powder metallurgy.

According to GE engineers the development of Lucalox will expand scientific, military, and industrial uses of ceramics. It may also extend the range of instruments and devices presently limited by the physical characteristics of available materials. One example would be high-intensity incandescent and discharge lamps, now limited by the heat resistance of their transparent envelopes in some cases. Fused quartz, often used for high-temperature lamps, performs satisfactorily up to 1800 F; Lucalox is stable at temperatures up to close to 3600 F.

Another possible application for Lucalox is in the banks of infrared lamps that test heat resistance of missile nosecones and other space-vehicle equipment. It may also find work as an electrical insulator and as a material for gem bearings in delicate equipment.

Present ceramic materials can be divided into three general categories: (1) **conventional ceramics,** such as porcelains, in which crystals are bonded together by low-melting glass —these approach, but do not reach, the 100% density of the new material. They are limited by the low melting point of the bonding glass. (2) **oxide ceramics,** more-or-less single phase—these are stronger than the porcelains, but, filled with light-scattering pores, they are opaque. (3) **single crystals,** such as sapphire and ruby—these are transparent, but are limited in size and shape and extremely difficult to fabricate. ■

Production Engineering in USSR Ahead of UK

LONDON—Research in production engineering in the Soviet Union is far ahead of that in the UK, according to a returning team of British production experts.

The USSR currently has about 10,000 scientists and engineers employed in this type of research, compared to about 300 in the UK and, among other things, has gained a 10-year lead over the British in automation, the British experts report. They are three members of the Production Engineering Research Assn of Great Britain, and made a 5-week tour of the USSR, Czechoslovakia and Poland.

They reported production research in Russia is being carried out at a number of organizations, each with facilities exceeding the combined resources available in the UK. Projects in these laboratories are ordinarily commissioned and paid for by individual Soviet factories.

The extensive coverage in Russia of foreign technical and scientific publications was also noted. The Soviets claim that a full-time staff of 1800 scientists and translators prepares digests and reports of articles appearing in 10,000 foreign journals. ■

Stinson Still Stinson but Nobody's Sure for Just How Long

SAN DIEGO—Stinson Aircraft Tool and Engineering Co—its production lines stilled—is seeking a new way to resume manufacture of the Charles Townabout all-electric car. The answer may be in producing most of the car in Japan.

Dr. Charles Graves, vice-pres of the company, said merger talks with a major auto manufacturer are still going on, but a proposed Sept 2 deadline was passed without a decision. Company officials have abandoned previously announced plans to get out of the business, he said. And unless merger talks take a new turn, they will seek reorganization.

Graves outlined these new plans: (1) Form a new corporation, capitalize it for $10 million and issue $2 million in stock immediately; (2) pick up manufacturing rights from Stinson; (3) use the San Diego plant for research only; (4) manufacture most of the auto in Japan; (5) possibly purchase batteries and electric motors domestically; and (6) delay for one year filling of orders for 110 US utilities and electrical firms.

Stinson had planned to start delivering the electric sportscar this summer to utilities for $2200 and start mass production by fall aimed at a general sale for $2800 (*PE—Nov 24 '58, p 27*). High vendor costs made this impossible, according to Deane Van Noy, company president.

Graves added the company could not compete cost-wise for labor with San Diego's expanding aircraft industry.

Graves said his men recently conferred with a group of Japanese industrialists about forming a Stinson of Japan Corp to manufacture most of the auto in Japan. He would only identify the executives as being industrialists from Tokyo.

One problem, he said, is to protect Stinson's design and features. ■

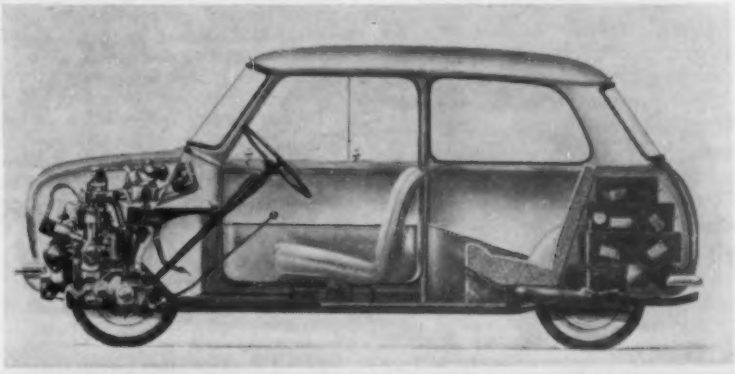
US Raises R&D Budgets by 12% in '59

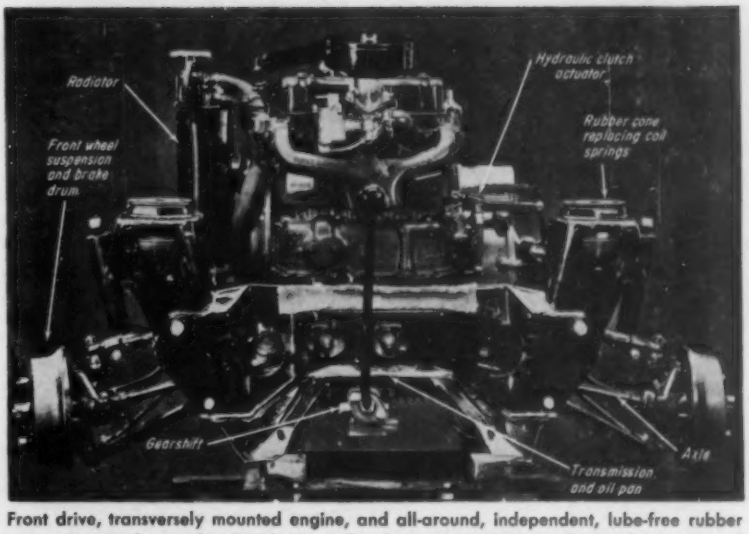
NEW YORK—Budgets for research and development in some 600 US corporations are 12% higher this year than 1958's record outlay, according to a survey conducted by the American Management Assn. Of firms studied, 64% increased budgets for development of new products and processes, 8% left budgets unchanged, 28% cut budgets. Last year's survey showed R & D budgets to be only 4% higher than 1957.

Among the 23 industry groups studied, automotive R & D budgets showed most increase—32% over last year. Three other industries had budget hikes of better than 20%—electrical machinery, 23.8%; instruments, 29.7%; and metalworking machinery, 21.7%. Only one group, miscellaneous machinery and parts, showed a decline. In 1958, six groups had a net budget decrease.

Expenditures for new products during 1958 averaged 3.2% of the sales dollar, according to the AMA survey, compared with 2.8% in 1957. The rubber industry topped all other groups with an R & D budget totalling 9.3% of industry sales. Next came general industrial machinery with 7% and a fair sprinkling of industries spending better than 4% (instruments, 4.8%; chemicals, 4.3%; and electrical machinery, 4.1%). ■

Compacting the Compacts–$1000 British Baby Car





Front drive, transversely mounted engine, and all-around, independent, lube-free rubber suspension are featured in British Motor Corp's Morris Mini-minor. Engine forms integral unit with the 4-speed gearbox and final drive, which all share the same lubrication system. BMC retained the 4-cylinder, overhead valve, watercooled engine of the Morris Minor, but shortened the stroke, reducing engine capacity to 850 cc and output to 34 bhp at 4500 rpm. Top speed is claimed to be 70 mph, with economy better than 50 mi/gal. when cruising at 50 mph.

COMING EVENTS

OCTOBER

1-2 . . . . Society of the Plastics Industry, Fifteenth New England Section Conference, Wentworth-by-the-Sea, Portsmouth, N. H.

5-7 . . . . Institute of Radio Engineers, Fifth National Communications Symposium, Hotel Utica, Utica, N. Y.

5-7 . . . . Institute of the Aeronautical Sciences and the Royal Aeronautical Society, Seventh Anglo-American Conference, Astor Hotel, New York City, N. Y.

5-6 . . . . Purdue Univ., Conference Packaging Specifications.

5-7 . . . . Joint Industry Fall Meeting of the Material Handling Institute, Inc Industrial Truck Assn. of Lift Truck and Portable Elevator Manufacturers, Lake Placid Club, Essex County, New York. State.

5-10 . . . . Society of Automotive Engineers, National Aeronautics Meeting, Aircraft Manufacturing Forum and Aircraft Engineering Display, the Ambassador, Los Angeles.

6-7 . . . . Electronics Industries Association, Value Engineering Symposium, Univ. of Pennsylvania Museum, Philadelphia, Penn.

6-7 . . . . Powder Metallurgy Parts Manufacturers Association, Sheraton-Caddilac Hotel, Detroit, Mich.

6-9 . . . . Stanford Research Institute, International Symposium on High Temperature Technology, Asilomer Conference Grounds, Calif.

7-9 . . . . American Vacuum Society, 1959 National Symposium on Vacuum Technology, Sheraton Hotel, Philadelphia, Penn.

12-14 . . . . National Electronics Conference, 15th Annual Meeting, Hotel Sherman, Chicago.

19-21 . . . . American Institute of Electrical Engineers, 11th Annual Machine Tool Conference, Sheraton-Cleveland Hotel, Cleveland, Ohio.

22-25 . . . . American Society of Industrial Designers, Annual Meeting, Grove Park Inn, Asheville, N. C.

26-28 . . . . Office of Naval Research, 1st International Symposium on Gas Lubricated Bearings, Shoreham Hotel, Washington, D. C.

26-28 . . . . Society of Automotive Engineers, National Transportation Meeting, La Salle Hotel, Chicago, Ill.

27-28 . . . . Society of Automotive Engineers, National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

Reader To Editor...

Saving Drafting Time

To the Editor:

I was interested in the article, "Measure Drafting Time," in the Aug. 31 issue, p 32. Some years ago I devised a method of estimating drafting time per drawing. The outlines of the method may serve as commentary to Mr Millenson's article.

A "drawing unit" was selected. This was the common stationery unit of 8½" by 11", also the size of the most common "A" drawing format. The "B" format was accounted two "drawing units"; the "C", four "drawing units"; the "D", format, eight "drawing units," etc. When a drawing was released to production, a record was made of the number of its "drawing units," the date, and the relative completeness of the information given the draftsman upon starting the drawing. After a year's tabulation of this data was acquired, average time per "drawing unit" was calculated. Where all necessary engineering information was provided at the beginning the average was from 10 to 14 "drawing units" per eight-hour day. Where all information was not provided, or was delayed, the average was from six to eight "drawing units" per day. High and low levels indicate proficiency levels. The year's work comprised several types and was done by draftsmen—not by engineering personnel breaking in as draftsmen.

Contrasted with my lowest average of 1 hour 20 minutes per "drawing unit," Mr Millenson's improved average of 2½ hours seems high. Students at the end of the freshman year at New Hampshire Technical Institute often average between 2½ and 3½ hours per "drawing unit."

I am aware of the necessity for turning out drawings at the lowest cost consistent with accurate communication. I question, however, the charge common in the industry, explicit or implied, that drafting is expensive. Expensive is defined by common usage as being excessive or costly of production. The question I pose is, On what scale or by what standard is drafting expensive?

—Maynard E. Creed, *senior instructor*
New Hampshire Technical Institute
Portsmouth, NH

Why Don't Engineers Join?

To the Editor:

Sometime ago you had an article calling attention to the fact that mechanical engineers are not very social-minded, not given to joining things. Looking at myself as an example, I can see the truth of your statements. Like yourself, I cannot fathom why this should be unless the complete absorption in work takes so much of our energies, and the satisfaction that we get therefrom does not leave us craving further recognition. However, I doubt that.

In your Aug 31 issue, you published a cover picture of the 102-man team that designed the Talos guidance radar. This picture made quite a hit with me although I do not know any of the men in it and have no connection with the project. It seemed to me that it dignified every one of those men and that their efforts are recognized.

—William L. Olsasky
Compton, Calif

Quackery and Optics

To the Editor:

Both A. E. Kimberly (May 18, p 25) and R. E. Schlemmer (Aug 31, p 24) seem to think we need a new principle to produce a glareless headlamp. The Laws of Optics, not man, dictate how any light-projecting device must be designed and constructed if it is to be glareless when viewed by human eyes from outside its main projected beam of light.

Why drift backward into quackery when the 2000-year-old Laws of Optics have never been proved to be in error?

—Milo C Caughrean
San Francisco, Calif

Drawing Courses To Continue

To the Editor:

In your Aug 31 issue, p 17, you said that, "Illinois Institute of Technology has eliminated courses in technical drawing." I am glad to report that Illinois Institute of Technology believes strongly in the value of technical drawing for science and engineering students, and I can tell you categorically that such courses will continue to be offered.

As a matter of fact, the technical drawing department here is known for its strong emphasis on sound and thorough training in this field. The department is the only one in the country giving BS degrees in technical drawing and MS degrees in engineering graphics. I am enclosing folders which described these curricula. Maybe you are thinking of MIT. For several years now they have not required any engineering drawing or descriptive geometry. These courses are given as electives and some students no doubt do take them.

—H C Spencer, *director*
Department of Technical Drawing
Illinois Institute of Technology

Correction

In the short article, "English Decimal System of Measurement" (*PE*—June 8 '59, p 90), G. G. Lips of Curacao proposes an English DINS system. It combines the principal base units (d)ram, (in)ch, and (s)econd with prefixes similar to those in the metric system, and abbreviates these combinations into handy terms. Thus the micro-inch (10^{-6} in.) becomes the "mikin"; the milli-inch (10^{-3} in.) the "milin"; and the kilo-inch (10^{3} in.) the "kilin." In editing, the statement was made that the system was based on the "mil" (0.001 in.) rather than the inch, so some values of the combinations were wrong. For these we apologize both to Mr Lips and to readers—Ed.

8 *steps to better engineering writing...*

1. . VANITY AND LAZINESS, BE SIMPLE
2. . BE POSITIVE, BE BRAVE
3. . BE PERSONAL, BE SPECIFIC
4. . BE CONCISE, DON'T OVERSTATE
5. . VOCABULARY, GRAMMAR, PUNCTUATION
6. . TABLES, FIGURES, CAPTIONS
7. . WHERE TO PUT WHAT
8. . SIT DOWN AND WRITE

RICHARD M. KOFF, *senior associate editor*

Lesson . . 4

Never "tell all."

This simple rule is one of the most difficult for engineers to follow, yet it makes good sense. The reader isn't interested in knowing everything you do about a subject—not by a long shot. Give him what he needs to know; nothing more. It's good psychology, too—you won't have to say "I don't know" to the questions an executive will always ask.

Careful omission of extraneous facts is half the battle. It cuts reports down to manageable size and makes concise writing at least possible. The other half is to omit needless words from the facts you decide are essential. William Strunk Jr., in *The Elements of Style,* wrote:

> "Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts. This requires not that the writer make all his sentences short, or that he avoid all detail and treat his subjects only in outline, but that every word tell."

No one can produce lean writing on the first try. It is difficult enough to get complex thoughts on paper at all. But once you have a sentence before you, it should be relatively simple to weed out the needless words, leaving the thought all by itself and in a form that every reader later will think is the only natural way to express it.

Much of what we have said in previous lessons will result in leaner writing. Be simple, be positive, be brave, be specific—all of these rules will contribute to more concise prose. In addition, there are some standard phrases editors have been trained to blue-pencil almost without thinking:

the fact that (because)	in order to (for, or to)
he is a man who (he is)	check up (check)
in the case of	drop down (drop)
from the point of view of	very
in regard to (about)	at the present time (now)
	this is a picture of (in captions)

And then add to this list those useless modifiers: entirely satisfactory, completely full, slightly pregnant.

At the bottom of this page you will find a letter liberally sprinkled with these phrases and how it might be pared. Is anything lost in the translation?

You respect the shorter-letter writer for several reasons: He writes (and therefore thinks) clearly and concisely. He does not burden the reader with unnecessary information. Also he does not "protest too much." No one could honestly be as apologetic as the first man pretends for three bad castings.

This rule, "don't overstate," means don't sell too hard, don't excuse with more reasons than necessary, don't explain too much. One or two excuses is enough—additional ones cast doubt. When the teacher asked Johnny why he was late for school, he answered, "Mommy's car had a flat tire, the bus didn't stop when I waved, and anyhow I got a splinter in my finger."

The splinter would convince you, the entire story wouldn't.

NOW YOU TRY

The best way to practice concise writing is to read with attention. Look for needless phrases, irrelevant information and overstatements in newspaper reports, technical articles and advertisements. Practice rewriting, mentally, the particularly bad examples. It's not hard, and it can reveal much faulty thinking by the author.

***Reprints** of this series will be available at the end of October. To reserve your copy, Circle P15 on the Readers Service Card.*

Dear Mr ------- :

It has been brought to our attention that this company's most recent shipment of sand cast pump housings was not up to our usual high standard. As a matter of fact, three housings were unsatisfactory by reason of the fact that dimensions in more than one case exceeded the allowable tolerances as given on your blueprints.

We are very sorry that so unfortunate and inconvenient an occurrence should have taken place and are ready and willing to rectify the situation as soon as possible. As in all such cases we will be happy to replace any and all such unacceptable castings with new ones. Please pack them up and ship them to us so that we can correct our molds and make new housings according to your drawings.

Apologetically yours,

Dear Mr ------- :

I'm told our latest shipment of pump housings includes three out-of-tolerance housings.

We're sorry

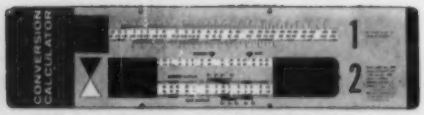
this happened

and if you'll return the

defective housings

they will be replaced.

Yours truly,



NEW! ANOTHER BIG BONUS IN ALCOA SCREW MACHINE STOCK

With the exclusive new Alcoa Conversion Calculator, it's a snap to find total costs and resulting per cent savings in switching to aluminum screw machine stock . . . in just three minutes or less. This handy slide-rule calculator does all the mathematical computations! Just set the part length at the stock size and read out the pounds of brass and aluminum per 1,000 pieces . . . with *automatic allowance* for 5 per cent operating scrap, 3 per cent bar end loss and 0.103-in. cutoff and facing loss. Then, determine your local material costs and—zip!—you've got the gross rod or bar costs for both metals. The reverse side of the calculator gives you an equally fast answer for the percentage savings when you switch to Alcoa® Aluminum.

Call your Alcoa sales office or Alcoa distributor today for an Alcoa Conversion Calculator. You'll find them listed in the Yellow Pages of your telephone directory under "Aluminum."

Your Guide to the Best in Aluminum Value

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

ALCOA ALUMINUM

And don't forget those many additional bonuses when you deal with Alcoa:

- Alcoa Aluminum Screw Machine Stock allows up to four times higher cutting speeds than other materials—up to 1,000 sfpm speeds.
- Wider range of sizes in standard stock for important price advantages.
- Stock in specific 12-ft lengths at no extra cost . . . in rounds to 2⅞ in. and hexagons to 2 in. across flats.
- Chamfered ends at no extra cost in a wide range of sizes and alloys.
- A guaranteed market for up to 60 per cent of your turnings and borings from four aluminum alloys.
- An extensive mill inventory to back up the nationwide distributor stocks and cover emergency requirements of mill customers.

Alcoa Aluminum Screw Machine Stock Alloys:

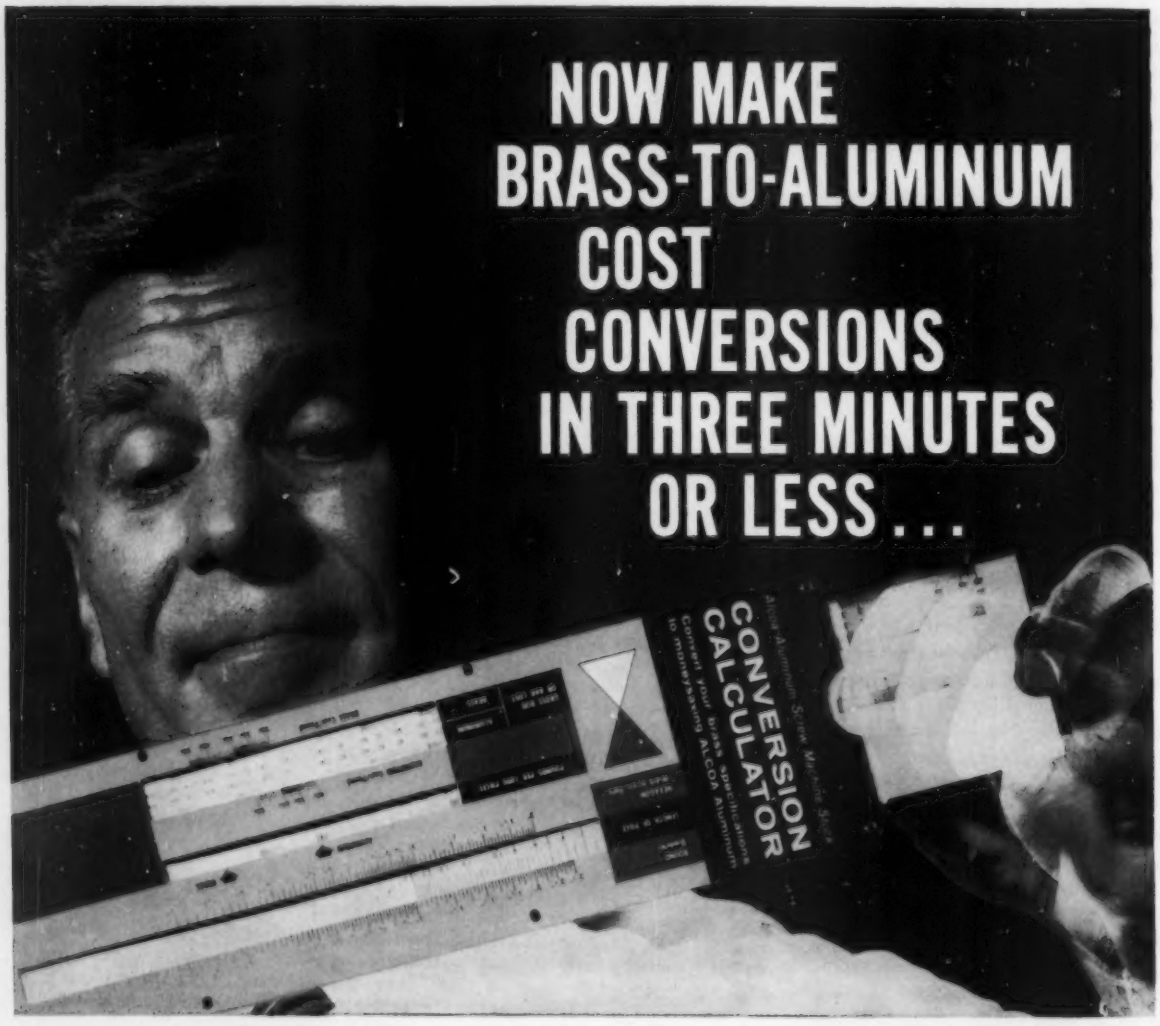
2011-T3: Tops in machinability. Frequently exceeds turning speeds of free-machining brass.

2011-T8: Designed for deep drilling operations. Maintains close tolerances.

2017-T4: One of the strongest alloys used for machine work. Chips readily controlled.

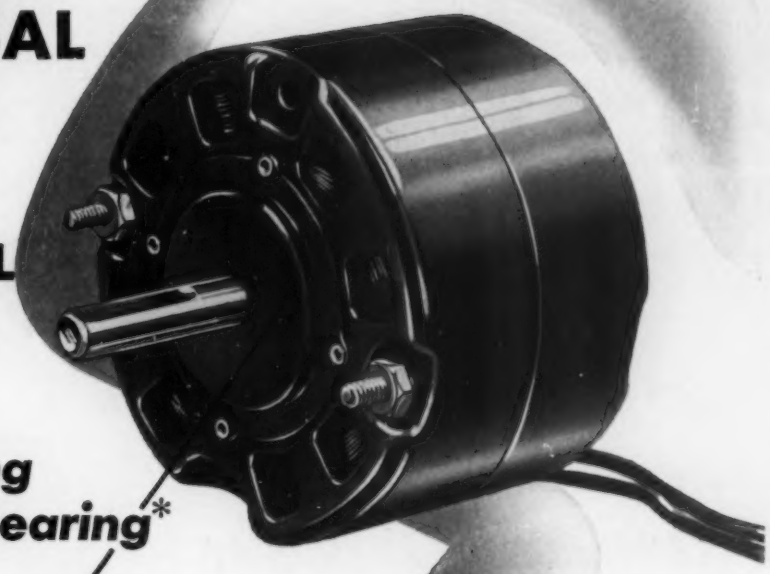
2024-T4: Exceptionally high strength. Cuts at high speeds and feeds for higher production rates.

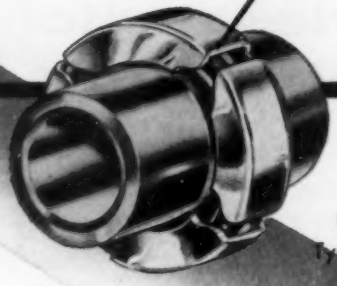
6061-T6: Excellent finishes possible. Resists corrosion.



UNIVERSAL ELECTRIC TYPE 118 FRACTIONAL HP MOTOR

*with new free-aligning Universal Bearing**





*PATENT APPLIED FOR

UNIVERSAL ELECTRIC announces a new, improved Type 118 four-pole, shaded pole motor featuring the NEW Free-aligning **Universal Bearing** that eliminates fractional hp motor bearing problems due to misalignment. With the axis of support in the center rather than at the end, and utilizing only the shaft itself for alignment, the new bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. The new bearing assembly provides longer bearing life, better lubrication . . . makes the Type 118 an easier starting motor that runs without a whisper of sound. More rugged and precision built from highest quality materials, the Type 118 is ideal for an unlimited number of applications that require maximum dependability with a minimum of maintenance, including kitchen ventilators, tape recorders, unit heaters, refrigeration equipment, window fans, record players, pump units, etc.

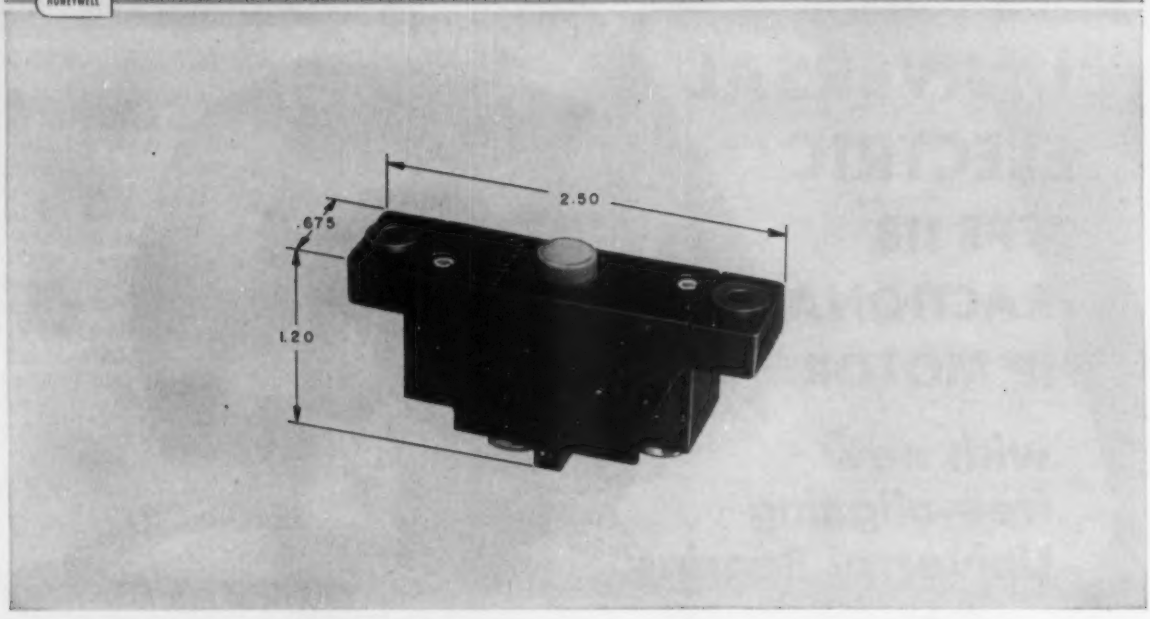
Write for complete information on the UNIVERSAL ELECTRIC Type 118 fractional H.P. motor and the new free-aligning **Universal Bearing.**

UNIVERSAL ELECTRIC COMPANY

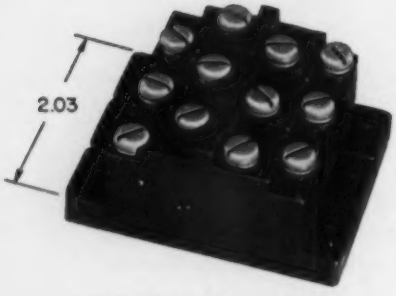
PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

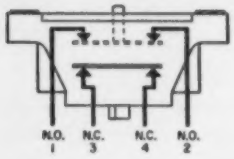
H HONEYWELL **MICRO SWITCH Precision Switches**



New "3MN" Series switches for machine tool controls



Bottom view of three switches shows compactness and staggered terminal pattern . . .



Contact arrangement is single-pole two-circuit double-break. Can also be used as a single-pole double-throw switch. Underwriters' Laboratories listed for: 15 amps, 120, 240, 480 or 600 vac; ½ hp, 120 vac; 1 hp, 240 vac; .8 amp, 115 vdc; .4 amp, 230 vdc. Pilot duty rating: 600 vac, max.

For complete information on these "3MN" switches contact your nearest MICRO SWITCH *branch office, or send for Data Sheet 164.*

. . . STACK IN SMALL SPACE

Step design case is only .675 in. wide. Three switches have combined stacking width of just over 2 inches.

. . . INTEGRAL TERMINALS

Terminal arrangement permits gang mounting without insulating barriers. The #8 terminal screws have captive lockwashers.

. . . LONG MECHANICAL LIFE

Median mechanical life is over 10,000,000 operations at full overtravel.

. . . PLENTY OF OVERTRAVEL

Overtravel is .080 in. min.

. . . EASILY MOUNTED

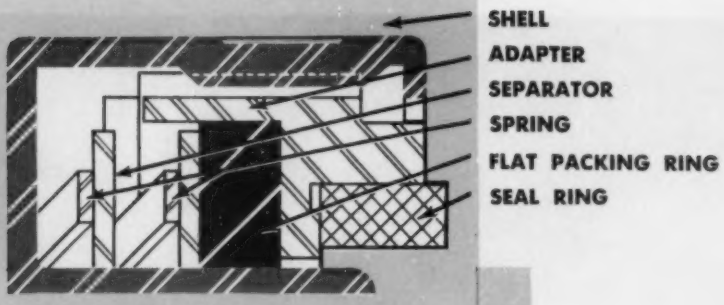
One mounting hole is elongated to eliminate the need for close tolerance in the center-to-center distance between mounting holes on the equipment.

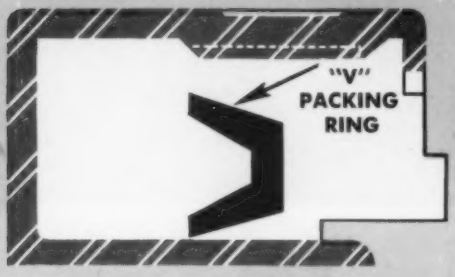
MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

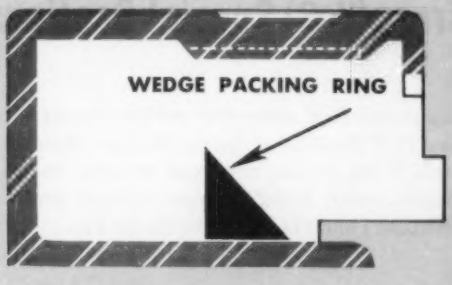
H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

CIRCLE NO. 35 READER SERVICE CARD →

GITS HH-TYPE SEAL SERIES







VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

GITS

Extra Flexibility For Your Seal Applications!

ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope — with your choice of the five seal packing arrangements illustrated at left — permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

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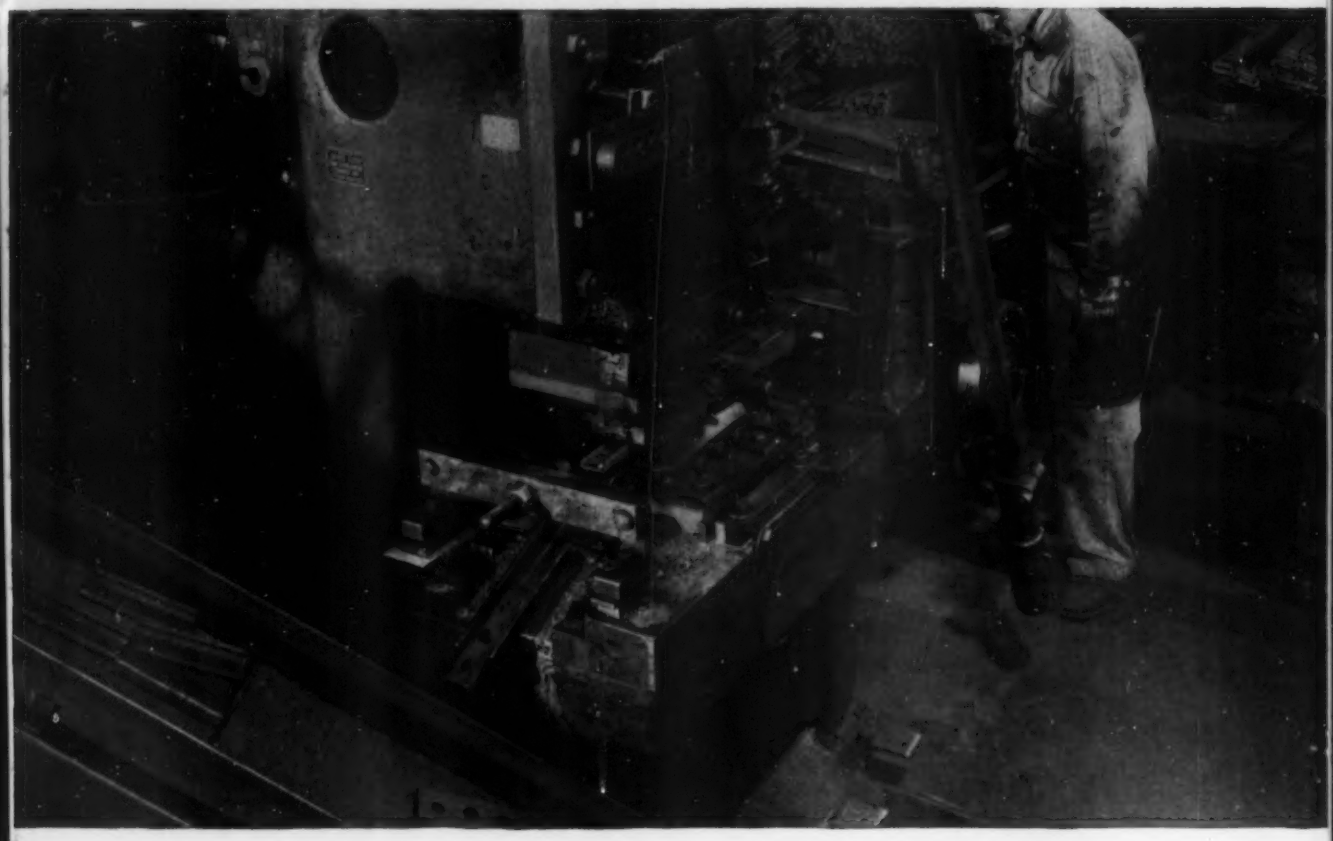
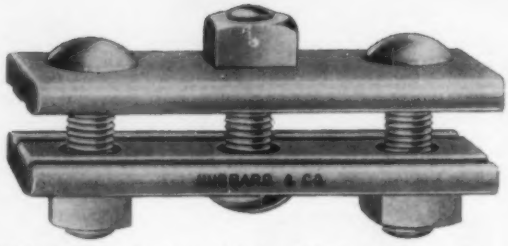
NEW! *Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.*

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



One automatic operation punches three holes and shears off the part from a USS Hot-Rolled Special Section. No machining necessary.



Hubbard pole line hardware made from USS Special Sections.

Pole line hardware • one punch • made from USS Special Sections

Hubbard and Company is one of the largest pole line hardware manufacturers in this country. They turn out guy clamps, cable suspension clamps and lashing clamps by the thousands. To keep production costs low, they use USS Special Sections already rolled to the proper cross section for the finished piece.

Many items can be punched and sheared in one automatic operation so that there is no machining and very little scrap. Parts can then be galvanized, bolts inserted and the job completed.

How USS Special Sections can reduce your costs. If you have an irregular steel part that must be produced in quantity at low cost, let us check your drawings. Many times a complex and costly assembly can be replaced by the use of one USS Hot-Rolled Special Section. Designs are unlimited. Write for our new book showing many intricate shapes already being produced. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS

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Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

United States Steel

PERSPECTIVES

in design and development . . .

Summit Notions

For two weeks now we have read, heard and televiewed Mr Khrushchev's romp across the American countryside. The whole point behind the original invitation was to give him a better understanding, and therefore respect, for American technology, resources and people. Let's look at ourselves through his eyes for a moment and see how well our purpose has panned out.

Our people must really have been a surprise to Mr. Khrushchev. The worker can hardly be considered downtrodden in this, the eleventh week of the steel strike. Our country is not ruled by gangsters or Wall Street financiers, and our people are freer with their opinions and criticisms than any he has ever seen before.

Score one for our side.

Our richness—in normal day-to-day living—must be almost unbelievable. Our "workers" live more luxuriously than Tzars. The quality and variety of goods and services that are within our reach will send our visitor home chastened somewhat, but surely with renewed resolve to meet and pass our standard of living no matter how difficult it may seem.

Score two for our side.

But in technology, impressive as the Pittsburgh steel mills and Idaho farm equipment may be, he knows we've already lost the race.

Dr Edward Teller wrote an article for the Associated Press awhile back saying with no equivocation: "Ten years from now Russia will be the unquestioned leader in the scientific field. This is something which I believe we cannot change, no matter what we do today. To educate a scientist is a long-drawn-out process. Young minds, the great contributors, are in greater number and they are better educated in the Soviet Union than they are anywhere else. And even if we bend all our efforts to change the present situation, all we can hope for is to regain lost leadership later. That we are going to lose our leadership is inevitable."

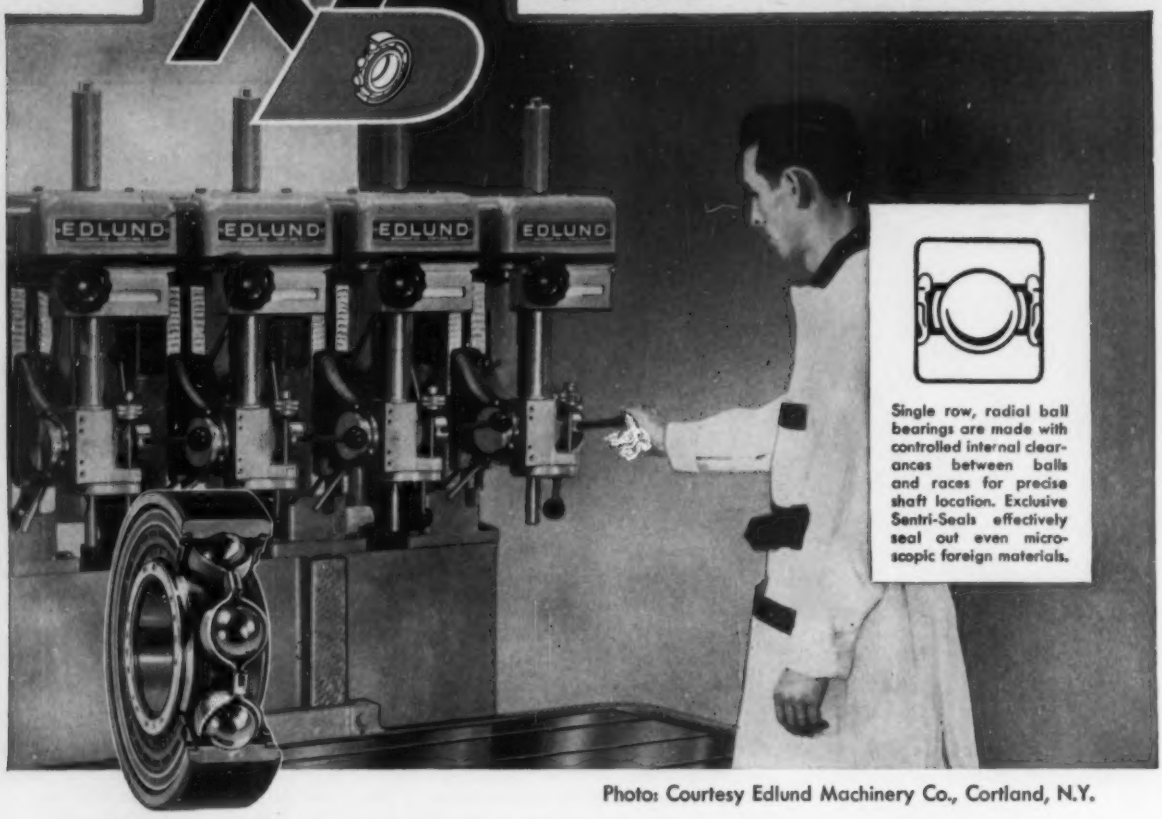
This is in basic science—not engineering and technology—and perhaps our forte has always been application engineering, "know-how" and the ability to get things done.

But we might as well admit it—we're soft. The high standard of living and freedom of choice are strong temptations to lead youngsters away from the rigorous ordeal of engineering and scientific education. Says Dr Teller, "The enjoyment of intellectual achievements is most definitely an acquired taste. You don't start out by liking classical music . . ." There must be an added inducement to drive the average student toward these fields. The Soviet Union uses a whip, a social whip of public opinion which makes of the scientist and engineer one of the most important and glamorous members of their society.

The designer, the engineer, the *doer* has far less prestige than movie stars in a society as rich as ours, and the situation is likely to remain so despite the cries of Dr Teller or Admiral Rickover.

The Russians will produce plenty of science for the whole world in the next few years—we're all bound to benefit. Simultaneously they'll enrich their own society, maybe beyond current Western standards. Then, lolling in the lap of luxury, won't they be closer to us in mind, in heart and in unjealous reason than they have ever been before? And won't *their* scientists complain of the laziness of the younger generation? —RMK

CASE HISTORIES



Single row, radial ball bearings are made with controlled internal clearances between balls and races for precise shaft location. Exclusive Sentri-Seals effectively seal out even microscopic foreign materials.

Photo: Courtesy Edlund Machinery Co., Cortland, N.Y.

Ball Bearing Design Adds Efficiency... Cuts Relube Maintenance In Drilling Machine

CUSTOMER PROBLEM:

Tool manufacturer requires minimum maintenance ball bearing design for new high-speed multiple drilling machine.

SOLUTION:

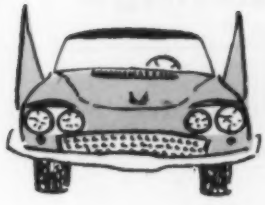
N/D Sales Engineer, cooperating with company engineers, recommended New Departure ball bearings with exclusive Sentri-Seals in place of conventional open bearings. These ball bearings, sealed and lubricated for life, virtually eliminated bearing relubrication maintenance. In addition, these sealed bearings accounted for a savings in parts and assembly time by eliminating costly lubrication plumbing and fittings. What's more, the application has proved so successful, the customer has had other types of drilling machines redesigned to use New Departures.

If you're working on new machine designs, why not call on New Departure? There's probably an N/D *production* ball bearing that will help you, and, at a lower cost! For more information write Department P-9.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

CAFE ENGINEERING IN DETROIT



"All fine cars have engines in front" . . . "There's greater safety in a front engine" . . . "An arrow has its weight in front" . . . "The front engine is a safety guarantee" . . . And so on. What's more, and vice versa.

So Detroit embarks on its latest copy-writing carnival, a field day in its peculiar dog-eat-dog school of promoting one's own products by invidious and vicious comparison, by insinuation and innuendo, by rumor and pseudo-engineering hogwash.

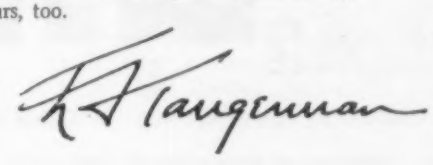
This is nothing new—it's just a little more blatant than usual. Most of the time such stuff is mildly amusing, but the cafe-engineering veneer on this sneer-and-smear campaign irks us. Any engineer worthy of the name is embarrassed if not outraged by such drivel couched in engineering terms.

Perhaps it is absurd to be the last angry man about automotive promotion, but somebody must be. This victory-by-vilification technique has gone on for years. Remember how your mechanics prof talked of the smoother qualities of 6-cylinder design—but to match 6-cylinder power with 4-cylinder experience and space, one maker made a V-8, and the race was on. We even had V-16's for a time. Now we're going back to sixes—and that may not be far enough in the face of superior economy and performance of threes and twos in foreign cars.

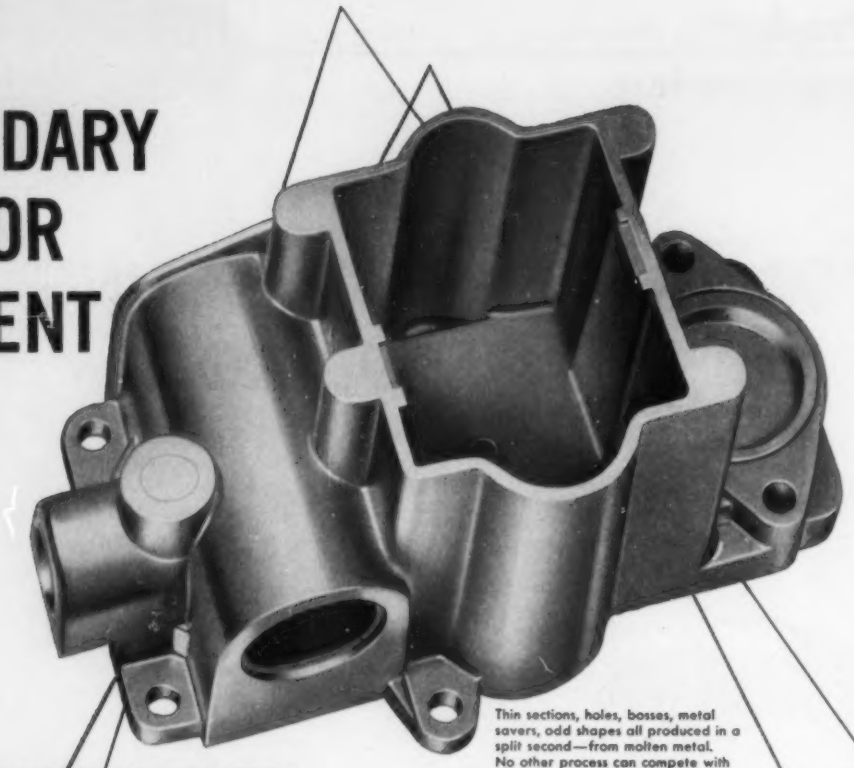
There have been similar races and cockeyed explanations of smaller wheels, lowered bodies, tail fins, tail lights, torsion-bar and coil springs, and other parts. The campaign of one small-car maker against the Big Three earlier this year had some vendetta overtones. But none of them have reached this pitch of vitriolic viciousness, nor dragged in engineering as a blood sacrifice so often.

As engineers, we'd simply like to echo Mercutio's "A plague on both your houses" (or all three) and forget the matter. But our professional reputations are involved. Engineers know that nobody has ever made a test, a race, or a speech that proved the engine should be at one end or the other—it's a matter of center of gravity and polar moments. There are good and bad cars in each category. We've owned front-engine cars that needed sandbags in back to hold the road, that bucked and plunged and slewed, that skidded on ice and squealed on macadam, that had center humps that made it necessary to carry midgets in the middle to bring the car to capacity. And we've seen little foreign cars with rear engines pull out of snow that our high-powered Detroit irons stayed in. And we've seen $400 repair bills for both types after a minor collision. So we don't take sides.

But the layman probably will. He won't remember that an arrow with its cg up front is counterbalanced by the bullet with its cg aft, that the cg of planes has moved from front to rear with the power plants. He has available no comparative statistics. So a "caveat emptor" situation is developing again. That, as such, is not our business. But misrepresentation of engineering is. And it should be yours, too.



LOW SECONDARY LABOR CONTENT



Thin sections, holes, bosses, metal savers, odd shapes all produced in a split second—from molten metal. No other process can compete with this for eye appeal or low cost.

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When product designers send preliminary drawings for critical review by the seasoned Madison-Kipp mechanics, it has often proved to be the decisive factor in the ultimate design of the component parts.

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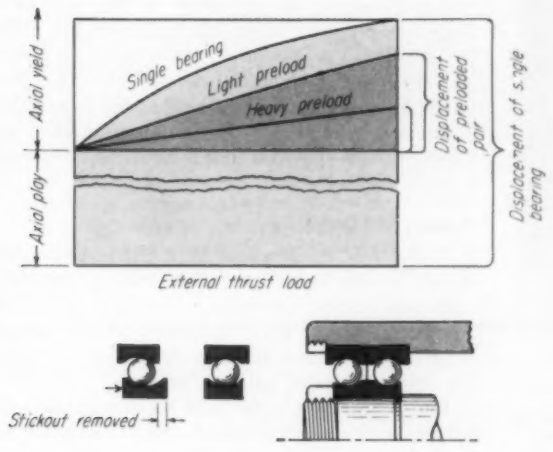
how to measure preload and play in **BALLBEARINGS**

Here's a roundup of special and commercial devices to check bearings for preload, radial play and end play. A previous article (Sep 14, p 78) discussed devices for testing torque, vibration and runout characteristics.

BRUCE L MIMS
Vice-president, engineering
The Borden Corp
Danbury, Conn



What Preloading Does

- Reduces axial and radial movements caused by variations in load. The typical load-displacement curve above shows that preloading reduces axial displacement drastically, completely eliminating axial play, important in gyroscope rotors and in precision spindles.
- Linearizes the load-deflection curve. Within the operating range the curve of the preloaded pair is flatter than that of single bearings—an important factor in some instrument applications.
- Preloaded bearings are usually employed in pairs, back to back, as illustrated, or separated by a sleeve. Amount of preload is built by removing "stickout" from the inner race.

Preload cannot be measured directly. A ballbearing is preloaded by applying a desired thrust load, measuring the "stickout" of one ring face beyond the other, and grinding off the stickout. When two such bearings are mated on a shaft and locked together they will push back with the original thrust load.

Once bearings are assembled, the preload can be measured only indirectly, by one of three methods:

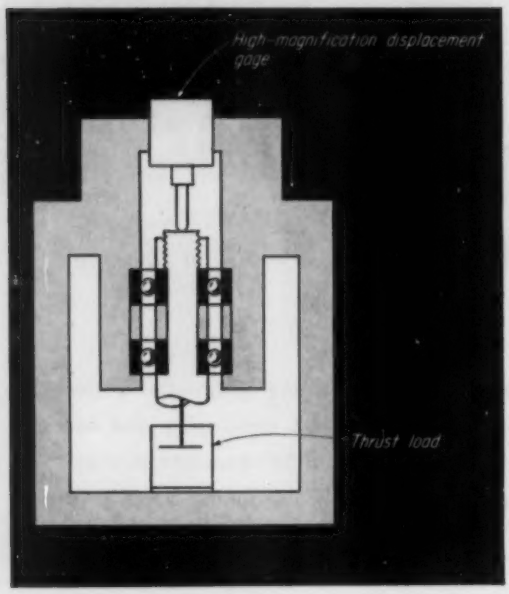
- Measure the axial deflection of the preloaded pair and relate this deflection to known load-deflection curves.
- Measure friction torque of the bearing under known loads.
- Measure contact angle under load and compare with previously determined data on relation.

These methods require a high degree of skill. In machine-tool applications, preload may not be sufficiently critical to warrant such elaborate checks; they are used only if knowing the exact magnitude of preload is important. There is no general agreement as to which of the three methods is best—each method has its proponents.

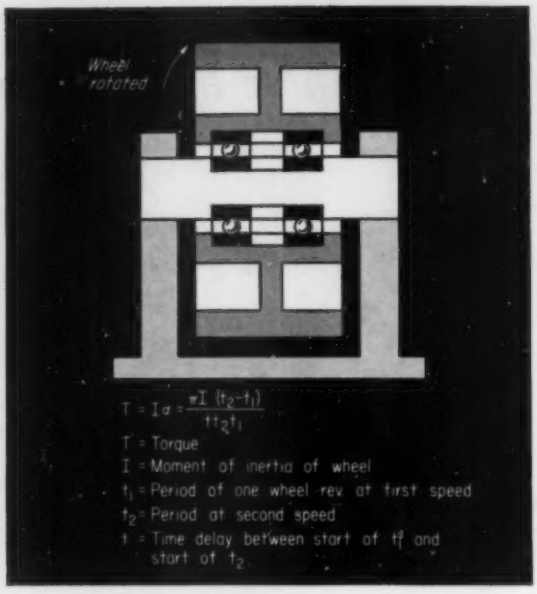
Preload from Measuring Deflection

Two devices are available commercially. One is made by Decker Aviation and is essentially a device to support a rotor and measure its axial displacement under desired axial loads

REPRINTED circle P10, inside back cover



Measuring axial displacement


Wheel rotated
$T = I\alpha = \frac{\pi I (t_2 - t_1)}{t t_2 t_1}$
T = Torque
I = Moment of inertia of wheel
t_1 = Period of one wheel rev at first speed
t_2 = Period at second speed
t = Time delay between start of t_1 and start of t_2

Measuring friction torque

in either direction. A capacitance transducer eliminates contact between the deflection pick-off and the rotor.

The other device, made by Pratt and Whitney, accomplishes the same result for preloaded pairs, but permits rotation of the bearings at any desired speed during measurement. While both of these devices are promising and useful, many bearing manufacturers and users prefer devices of their own design.

Preload from Torque Measurement

The required time for a rotor to coast to a stop has long been used as a measure of preload by gyro manufacturers. It has disadvantages: Bearing-friction torque varies with speed–particularly at high speeds. Therefore overall coast time is but a crude integration of this nonuniform deceleration. Further, windage is high at high speeds and magnetic drag may affect the coast time. The main advantage of coast-time testing is simplicity.

Instead of coast time, a much better method is to time two successive rotor revolutions or half-revolutions at a speed in which bearing torque is relatively insensitive to speed change–usually in the 500 to 1500-rpm range where windage and magnetic drag are also low. Torque can be calculated from the change in time-per-revolution during a few seconds coasting, as shown in the diagram. A combination of off-the-shelf electronic equipment can be set up to make this measurement.

Both tests give bearing torque at a given measuring speed, not preload. Bearing torque must be converted to preload by reference to preload-torque curves; or more accurately, by measuring the torque of each bearing under a range of loads, a costly procedure.

Contact Angle Method

This method of indirectly measuring preload is sometimes employed, but we do not recommend it. The angle is measured under various thrust loads and a curve plotted. After the bearing is preloaded in its assembly, the contact angle is again measured and the load noted from the curve. However, the sensitivity of this method is low because the contact angle, changes so slightly with load.

Yield rate has also been used to measure preload but the technique is expensive and difficult. The preload is found by vibrating the bearing-supported mass and finding the resonant frequency–which is dependent on preload. One gyro wheel design has been successfully preloaded by this method.

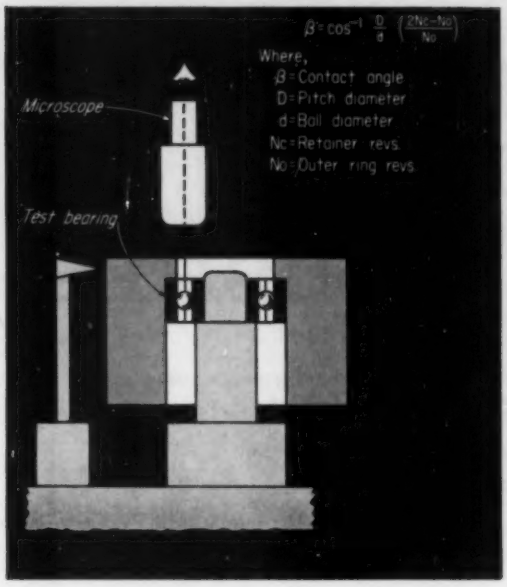
Radial and End Play

Radial play is measured by applying a specified load to the bearing inner ring while holding the outer ring stationary (or the opposite). The load is applied first in one direction, then the other. Total excursion is radial play. Several readings should be averaged, and the bearings rotated between readings.

End play, which is the axial motion of one ring with respect to the other, is not strictly a functional test–no more than is radial play. Measuring them establishes little about the bearing except conformance to a design specification. Yet radial play is often measured by ball-bearing users, possibly from habit, and is included in some ball bearing nomenclature–for example, the "5" in R2D5. Some have confused this with the "5" in ABEC designations and attributed ABEC 5 tolerances to the bearing without justification.

Although the need for a radial play measurement is debatable, there should be doubt of its importance in the bearing. Ballbearings will not run well with zero or negative radial clearance. When bearings are mounted with press fits, some of the original radial play within the bearing is lost. Differential expansion of shaft, bearing or housing can produce the same effect. Also, radial play

DETERMINING PRELOAD



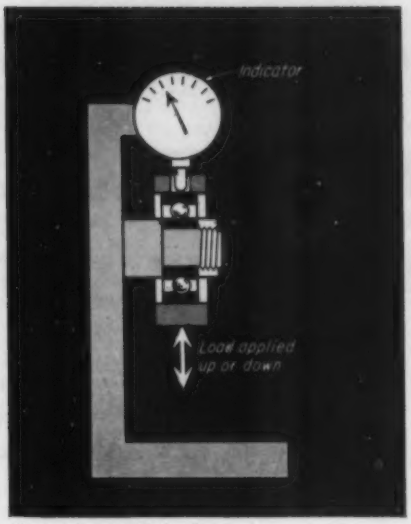
Measuring contact angle

in combination with the curvature across the raceway determines contact angle, which in turn affects torque, yield rate and internal compressive stress.

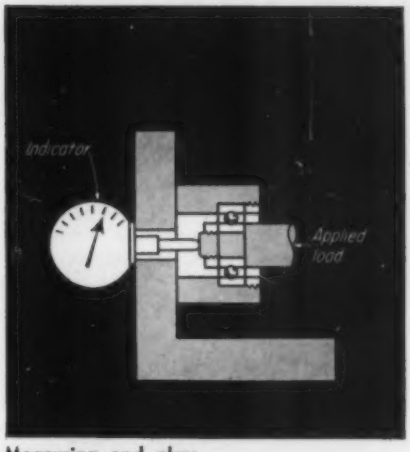
At least two manufacturers, Federal Products Corporation and the Sheffield Corporation, sell radial play gages, and many ballbearing manufacturers have proprietary designs.

REPRINT. This article, combined with the preceding one in the Sep 14 Design Issue, covers the full range of testing methods and devices for problems encountered in applying ball bearings. For a combined reprint of the two articles check p 10 on one of the Reader Service cards bound in this issue.

Preloading also helps bearings absorb shock. For this and other methods see "How to Reduce Shock Loads in Bearings," Sep 16 '57, p 72.



Measuring radial play



Measuring end play

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PRODUCT ENGINEERING DESIGN MANUAL, by Douglas Greenwood, Associate Editor. 340 pages, 8½ x 11. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. $9.

how to write...

SPECIFICATIONS FOR ANODIZED FINISHES

Change the aluminum alloy, its surface preparation or the coating process and your finish can change—in how it looks (see cover) and how it performs. Here's a practical guide to specifying finishes so you'll get what you want.

R V VANDEN BERG

Alcoa Process Development Labs
Aluminum Company of America
New Kensington, Pa

Anodizing for appearance alone is giving way to anodizing for appearance plus function. This trend calls for greater attention to specifications covering the three main design choices—the alloy, its surface preparation, and the process itself. The problem is to make these choices and embody them in a concise, unambiguous specification. Here are the practical aspects of anodizing—with reference charts and an example problem that show how to do it.

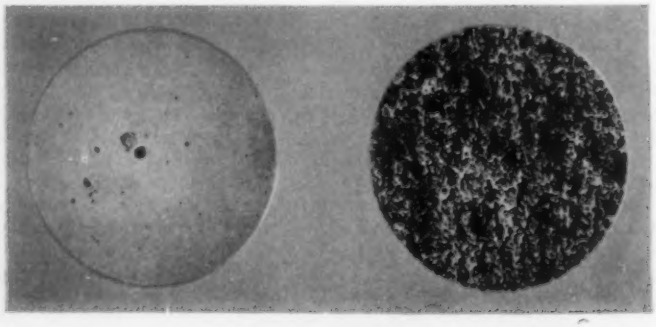
ALLOY SELECTION

Aluminum alloy constituents and impurities influence both the appearance and performance of an anodized coating. The more important elements are: silicon, iron, manganese, magnesium, chromium, copper and zinc; and these components may be dispersed, in solid solution, or in various stages of precipitation. Reactions that take place with these components during anodizing depend on composition of the electrolyte, its concentration, temperature and condition. The alloying constituent may be totally unaffected or it may be completely dissolved by the anodizing process; it may be partially oxidized or completely oxidized. Whatever the change, it can greatly influence the finished coating.

Appearance

Apparent color or shade of an anodic coating is affected by lustre or opacity. Maximum lustre or brightness is obtained on high purity aluminum. Lustre suffers if certain alloying elements are present, but elements in solid solution give best brightness. Table I ranks the common alloys in the order in which they produce bright coatings.

Alloying components and their oxidation products have their own natural color tendencies, and these may cause off-color tints that disturb color match. On the other hand, these natural tints can be used to advantage: to produce an unusual variant to a colored finish, to provide a tint to a clear coating, or to give a color obtainable in no other way. Three alloying elements have pronounced tinting tendencies: chromium oxidizes to produce a yellow tint, manganese gives a brownish tint, and silicon in its elemental form turns coatings gray or brownish-gray—one of the newer decorative colors.



Coating transparency . . . determines metallic lustre, and depends on purity of aluminum: Clear coating at left is on aluminum sheet 99.95% pure; coating at right is clouded by presence of silicon, iron and manganese in 99.2% pure metal. (× 100)

Table I—Wrought Alloys For Bright, Metallic Lustre

Alloy	Type	Remarks
99.99	Pure Al in sheet, plate or extrusion	Give brightest lustre since oxidized surface is free of Si, Fe and Mn which normally obscure polished surface. Easily formable, but low in strength and expensive. Used primarily for simulated gold finish. Super-purity Al-Mg and Al-Mg-Si alloys give the same brightness; cost is still high, but strength is much improved because of Mg additions.
5357 5457 X5557	Mg alloys in sheet form	Lustre is below that of high-purity Al-Mg alloys, but they respond well to anodizing, have good mechanical properties, and are priced for commercial applications like automotive and appliance trim. Alloying constituents do not tint coating.
6063 6463	Extrusion alloys	These heat-treatable alloys combine high strength and good response to anodizing. Contain Mg and Si as MgSi. Heat treatment dissolves silicide, improving strength and lustre after anodizing. Presence of excess Si can give coating a gray or brown tint. Applications include: automotive, appliance, architectural, trim.
1100 5005	Sheet and plate	Alloy 1100 is commercially pure Al, but has some Si and Fe which diminish lustre under anodized coating. Presence of Si can give coating a gray or brown tint. Alloy 5005 has some Mg for modest strengthening.
3003	High-Mn alloy in sheet or plate	This commercial alloy has excellent formability and, though widely used for anodic finishing, has less as-anodized lustre than 1100 or 5005 because of Mn and lower Al purity. Since MnO is brown, anodized films on this alloy have brownish tint.
5052	Mg alloy in sheet or plate	Structural alloy containing Cr as well as Mg, widely used for welded parts. Presence of Cr gives thicker anodic coatings a yellowish tint.
6061 2014 2024 7075	Extrusion, sheet and plate	Heat-treatable, these alloys rank after 5052 in lustre because Al purity is lower. Cr in 6061 and 7075 gives thicker anodic coatings a yellowish tint.

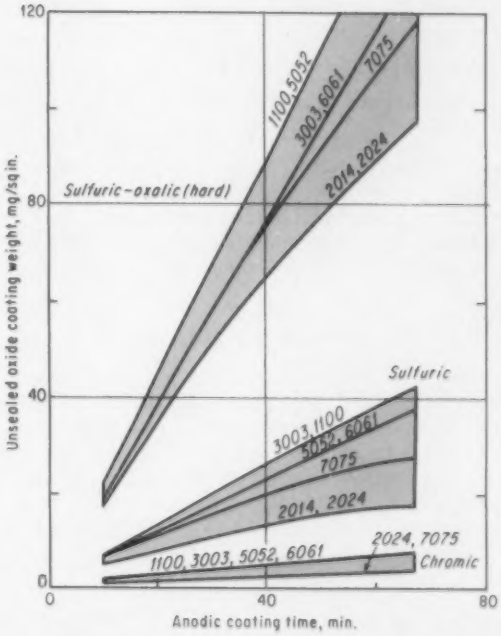
Silicon is one of the most important constituents since it is so often present in commercial aluminum—either as an impurity, or as an alloying component to give toughness to cast and wrought parts. Silicon does not dissolve or oxidize under normal anodizing conditions, and its own gray color shows through anodized coatings as a gray or brownish-gray color depending upon the size and distribution of silicon particles.

Silicon can be used intentionally to produce a gray anodic coating: wrought alloys containing about 5% Si are now applied to architectural parts. But this graying tendency can cause problems, too: fillets of welds made with aluminum-silicon rod will be gray after anodizing, thus causing nonuniform appearance. (Special welding procedure and welding wire can minimize weld discolorization.) Where color is critical on welded parts, anodizing specifications should omit pre-etching.

Castings Are Different

While the effect of alloying constituents on appearance of anodized coatings on castings is the same as for wrought alloys, differences in microstructure—grain size, porosity and segregation—have an effect on appearance. Because grain size in castings is larger, castings seldom achieve the smooth, bright finish of anodized wrought alloys. Further, normal brightening techniques tend to roughen cast surfaces. Porosity, especially if it is fine, will trap the electrolyte and interfere with colored anodic coatings.

Structural streaking is a problem with diecast alloys and with wrought alloys in the form of thick plates. In



Process and alloy . . . fix coating weight for given anodizing time. Some alloys respond much more than others. Bottom curves: chromic acid electrolyte; middle curves: conventional sulfuric acid electrolyte; upper curves: sulfuric-oxalic acid mixture.

Table II — Mechanical and Chemical Pre-treatments

Designator	Type of Surface Preparation
	MECHANICAL
No Suffix	As-fabricated surface
A1	Preliminary grinding and polishing prior to buffing
A2	Buff directly on as-fabricated surface
B	Polish finish (round tubing only)
C1	Polish finish, No. 180-220 emery or finer
C2	Satin finish, hand rubbed with steel wool
C3	Satin finish, compound or brushed backed sander
D	Polish finish, No. 140-180 emery
E	Polish finish, No. 120-140 emery
G1	Very fine sand blast (formerly "Dust Blast")
G2	Fine blast
G3	Medium blast
G4	Coarse blast
K	Wire-brush finish
M	Burnished finish
N	Sand-burnished finish
	CHEMICAL
R1	Caustic etch
R2	Caustic etch for diffuse reflectors
R3	Sulfuric-chromic etch
R4	Bright dip (nitric-hydrofluoric)
R5	Bright dip

diecastings, anodizing emphasizes flow lines frozen into the part during casting; streaking in thick plates occurs during rolling. Specialty sheet products can be obtained when necessary to minimize this effect.

Mechanical Aspects

Heavier anodic coatings give higher resistance to abrasion and corrosion, but some alloys tend to form thinner, less durable finishes, shown earlier in the curves for three anodizing processes. But coating thickness is not the only factor: cost, formability, strength and appearance may be equally important in selecting the right alloy.

SURFACE PRE-TREATMENT

Anodic coatings reproduce the texture of the surface from which they are formed, because anodizing is a surface conversion process. Thus a specification includes surface pre-treatment as well as the coating itself. Pre-treatment techniques are mechanical, or chemical, as summarized in Table II, which shows one commercial designation system. Since texture is hard to specify in quantitative values, appearance samples must be made a part of the specification.

Mechanical Treatments

Buffed surfaces are mirror-like and shine through anodized coatings, colored or clear, with the brightest, most metallic lustre. Buffing requires three steps: polishing to remove surface irregularities, buffing to smooth the surface, and electro- or chemical-brightening for maximum lustre after anodizing. The final finish is not optically

flat, and large surfaces require specialized equipment for a uniform appearance. Contoured surfaces can be difficult, too, if there are recessed areas difficult to reach with a buff.

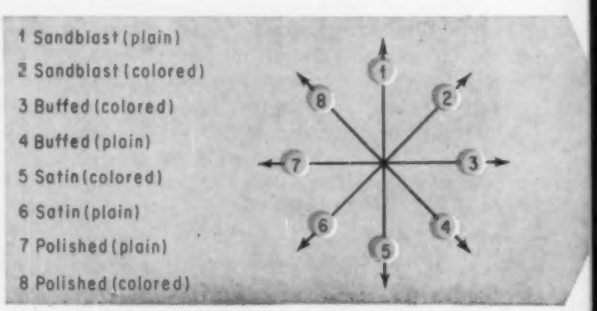
Polishing stops just short of buffing, and produces a soft metallic sheen with barely perceptible directional characteristics. Abrasive particles imbedded in a wheel or belt leave a series of fine parallel scratches in the surface. Large flat surfaces may be polished with special equipment. Extrusions polish satisfactorily as long as abrasive can reach all recessed areas. This finishing technique has functional advantages too: rough surfaces can be brought within tolerance, and localized stress raisers in welded joints can easily be removed.

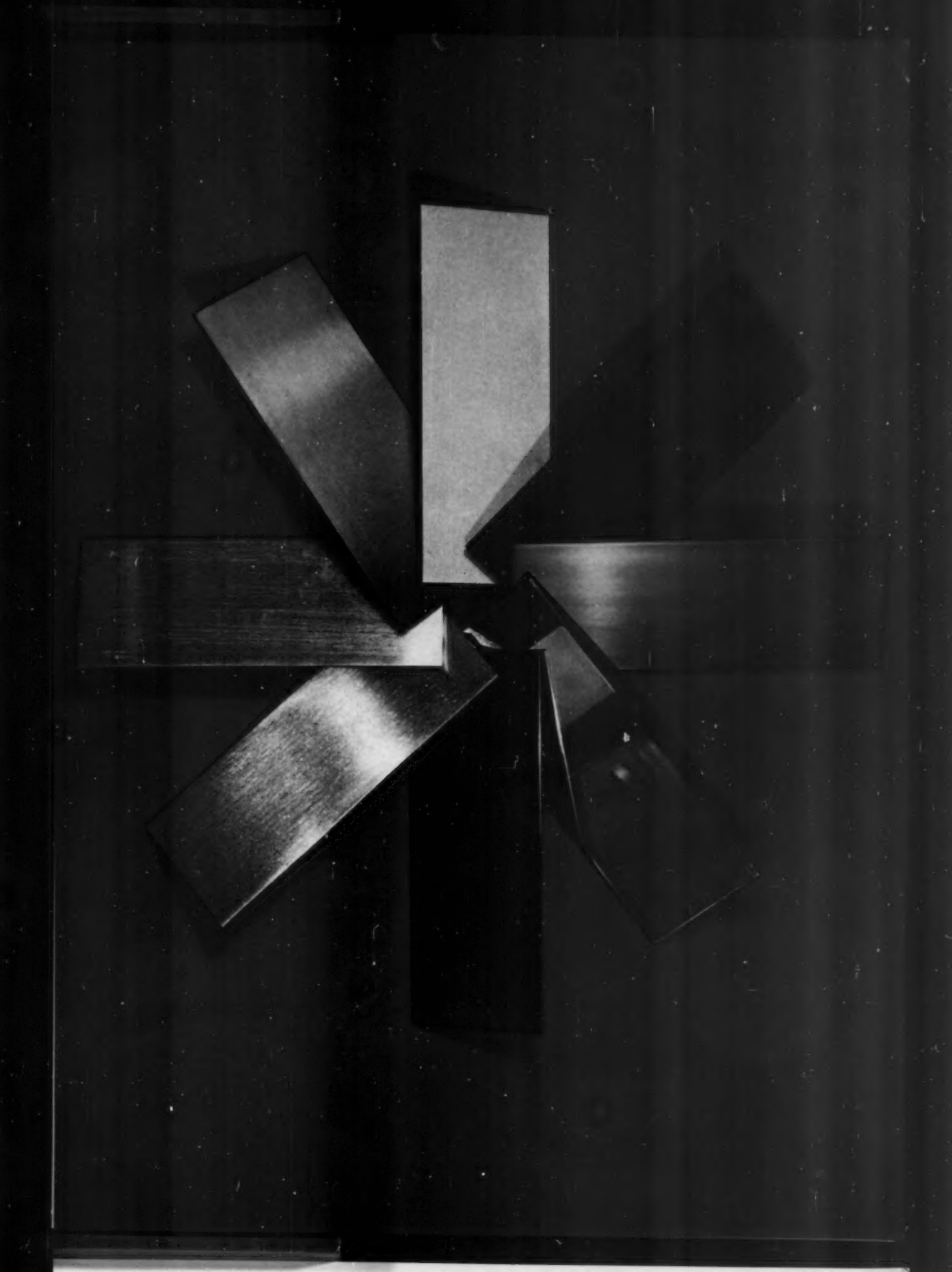
Satin finishes are usually not as directional as polished finishes since they are applied with abrasives on flexible carriers like stainless steel wire brushes or brush-backed sander heads. With the finer abrasives, the two finishes often look much alike. Flexible brushes can finish fairly complex contoured surfaces but care is required to obtain uniformity on any large surface. Decorative appeal is the main reason for specifying a satin finish, but the finishing operation will also de-burr sharp edges.

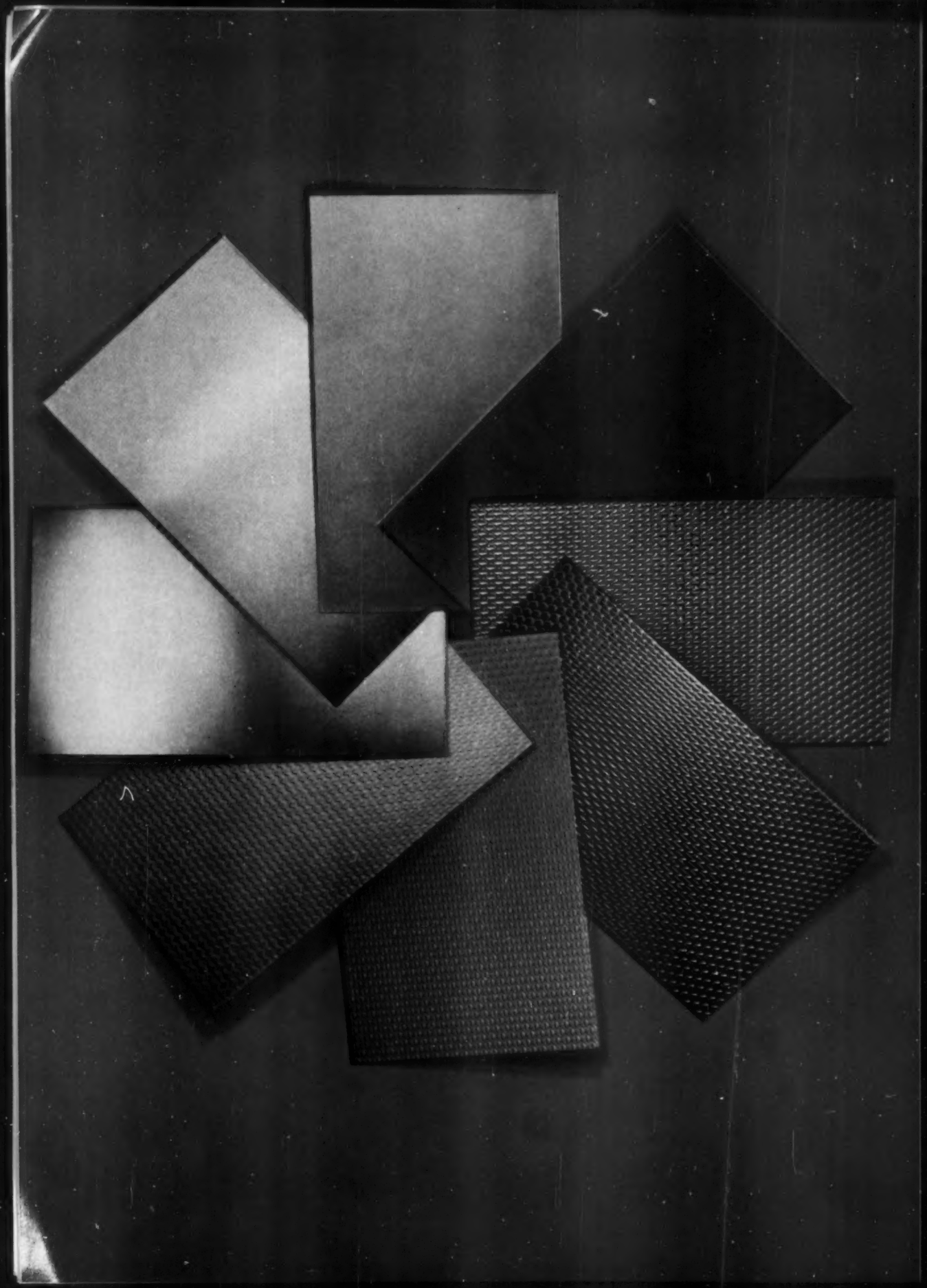
Burnishing is another type of satin pre-treatment, and is performed by three methods. **Barrel burnishing** is a simple and low-cost method, particularly suitable for small parts; symmetrical parts give more uniform brightness—a key feature in anodizing. **Tray burnishing** uses an abrasive water mixture through which the aluminum —usually flat sheets or castings—is sloshed to produce a uniform matte finish. **Loose abrasive finishing** overcomes some of the limitations of barrel burnishing: parts are mounted in fixtures which rotate within a flowing slurry of abrasive so the moving abrasive can reach all surfaces.

Sand blasting produces a matte surface. The finest matte finishes result from vapor honing: a slurry of fine abrasive and water is thrown against the work by air pressure. Steel shot or grit is seldom used with aluminum because of its cutting action, but shot blasting will give a peened decorative effect. Such shot blasting of

Mechanical pre-treatments . . . alone give these four different colored coatings from the same color anodizing process— from ceramic-like matte surface (2) produced by sand-blasting, to satin sheen (5) given by wire brush and abrasive.







ANODIZED FINISHES (CONTINUED)

large flat sheets induces residual stresses which cause warping. This is no problem with plate structures, castings or forgings—and residual stresses may improve fatigue resistance. A uniform finish requires close control of nozzle movement and position—one reason why large flat areas are not often finished this way.

Special patterns can be rolled into aluminum sheet by coining, deep-texturing or crimping. These effects were covered in an earlier article "Color and Textures for Aluminum" (See PE–Sept 30 '57, p 101).

Chemical Treatments

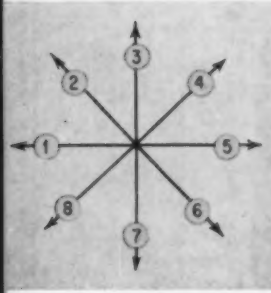
These include a wide variety of acid and alkaline etches, usually classified according to whether they produce a matte or a bright surface. Basic types are shown in Table II.

Matte finishes are most economically produced with a caustic etch employing 5% caustic soda solution at elevated temperature. This treatment, designated R1, can also be used for simple cleaning prior to anodizing. Acid mixtures of the chromic-sulfuric acid type, designated R2, also produce an attractive matte surface with 2-5 times less metal removal than the conventional alkaline etches. This treatment removes heat treating and water stains without taking off much metal. For a matte etch on heat treatable alloys, an R3 etch is used prior to caustic etching to remove oxide films for a more uniform response to the R1 etch.

Mixtures of nitric and hydrofluoric acids also produce attractive matte etches, but the metal removal rate is so high they are generally reserved for casting alloys containing silicon. Phosphoric and chromic acid mixtures, when used at boiling temperatures, will remove oxide or anodic coatings with no attack on the aluminum substrate. They are important when salvaging rejects whenever close dimensional tolerance or retention of original finish is required.

Bright finishes by their nature are less critical than matte finishes: in small areas they tend to "blind" the eye with reflected light. There are two main bright chemical finishes: R4 is a mixture of nitric and hydrofluoric acids, and R5 uses nitric and phosphoric acids, a common dip for automotive or appliance trim. Both R1 and R3 etches can be used for cleaning purposes, if metal loss is not critical. Metal loss can be minimized and original texture maintained by specifying a secondary rinse in inhibited solvent, solvent emulsion or by vapor degreasing.

Chemical pre-treatments . . .
give more subtle differences in final coating—compare bright gold finish (2) anodized on top of acid etched panel (1) with matte gold finish (4) anodized over caustic etched panel (3). Panels (5) through (8) are the same two finishes, before and after, on patterned sheet.



1 Bright acid etch (plain)
2 Bright acid etch (colored)
3 Matte caustic etch (plain)
4 Matte caustic etch (colored)
5 Bright acid etch on texture (plain)
6 Bright acid etch on texture (colored)
7 Matte caustic etch on texture (plain)
8 Matte caustic etch on texture (colored)

Table III — Combination Pre-treatments

Designation	Operations Involved	Common Uses
A1R1	Buffing followed by caustic etch	Appliance
A1R5	Buffing followed by bright dip	Automotive Trim Appliance Trim Jewelry
C1R1	180-220 grit polish followed by caustic etch	Hardware
G3R1	Medium sand blast followed by caustic etch	Firearms Optical Goods Metal Decorating
R1R5	Caustic etch followed by bright dip	General Cameras Giftware Appliance
R3R1	Sulfuric-chromic etch followed by caustic etch	General
DR1	140-180 grit polish followed by caustic etch	Architectural
C3R1	Satin finish followed by caustic etch	Hardware

Combination Pre-treatments

Combinations are often specified as shown in the nomenclature system of Table III. For example, if a buffed A1 surface requires an R5 bright dip to give the desired texture, the complete designation is A1R5. This is used for the brightest, most metallic lustre, but anodizing this surface pre-treatment will not give the brightest surface since residual abrasive makes the anodic coating opaque. By adding a chemical or electrochemical brightening process to the specification, contaminated metal will be removed and the surface will convert to a more transparent anodic coating.

WHICH ANODIZING PROCESS?

Two basic ones stand out and are used most widely: dilute sulfuric acid and dilute chromic acid. They differ in the kind of coating they produce.

Sulfuric acid in dilute (15% by weight) solution produces plain or colored coatings on most all wrought and cast alloys, and gives coatings about twice as thick and twice as dense as those from chromic acid solutions.

Chromic acid, also in dilute (5-25% by weight) solution gives anodic coatings with an attractive ceramic-like quality. They are opaque and gray in appearance, but can be readily colored. Alloy choice can be critical with chromic acid anodizing: alloys containing over about 7% total alloying content or over 5% copper do not respond well. As a general rule, castings should not be treated with chromic acid anodizing baths.

ANODIZED FINISHES (CONTINUED)

Extra-thick and dense coatings are produced by a variation of the sulfuric acid technique. Called "hard" anodic coatings, these finishes result from anodic treatment in a sulfuric-oxalic acid mixture, and range in thickness up to 2 mils–about 10 times the top thickness for conventional sulfuric acid coatings. Accompanying curves compare hard and conventional sulfuric acid finishes for a wide range of immersion times. Hard coatings give the best resistance to abrasion, corrosion, and erosion. Though good thermal and electrical insulators, hard coatings tend to craze under temperature change because of extreme thickness. Color of the natural hard coating varies from light gray to dark brownish-gray, depending upon alloy. These colors are finding decorative applications.

Processes Cause Design Problems

Surface build-up from the anodizing process, while not as great as with electrodeposition processes, can cause trouble on close tolerances. For chromate coatings, this increase in surface dimension is slight. For conventional sulfuric acid type coatings, surface growth averages ⅓ the thickness of the anodic coating. For hard anodic coatings, an increase in surface dimension of ½ the coating thickness can be expected. These rules don't apply to blind holes or tubing–throwing power is limited.

Surface smoothness has an important effect on coating thickness–smoother surfaces produce thicker coatings. Sand castings, for example, must be buffed to give coatings as thick as those on wrought alloys. With hard anodic coatings the effect is even more noticeable. Also, when hard coating tends to roughen smooth surfaces, lapping or honing the anodic coating will restore the original smoothness, if required.

Parts with non-aluminum components should be checked carefully. Non-metallic components, plastics for example, cause no difficulty unless they insulate or divide the aluminum part so that current flow is stopped from one metal area to another. Inserts of steel, stainless steel, brass, bronze or any metal except titanium or lead will be dissolved in anodizing. Such inserts should be installed after anodizing.

Different aluminum alloys in the same part can cause mismatch problems, because the various alloys react to the process differently. Aluminum-magnesium casting alloys in particular have a different anodizing rate than wrought alloys. This can result in appearance mismatch after anodizing, or unequal performance of the mating coatings because different coating thicknesses and densities. Mix only alloys which are known to react alike, or test a prototype assembly in the proposed bath.

Fatigue strength is affected by thick anodic coatings. On smooth surfaces, coatings less than 0.1 mil thick have little effect; thicknesses of about 0.5 mil have some effect at high stress levels. Hard anodic coatings, being thicker, reduce fatigue strength considerably–particularly at high stresses. Tensile strength also declines slightly with increased coating thickness.

WHAT ABOUT COLOR?

The porous cellular structure of anodic coatings is what permits coloring. With as many as 500 billion pores per sq in., these coatings will readily absorb water or solvent solutions of organic or inorganic dyes. Coatings differ, however, in their acceptance of color. Sulfuric or chromic acid electrolyte coatings (the former transparent, the latter opaque) give a wide variety of colors and shades–including black. But hard anodic coatings, because of higher density and lower porosity, will take only limited color; coatings are dark gray as formed, and bright clear colors are impossible.

Quantitative specification of color for anodic coatings is complex. Although instrumentation is available, measurement or matching of color is still considered largely an art. Use of control samples that illustrate the desired combination of surface texture, color and shade is the best practical approach. These can define the range of shade tolerance for inspection purposes. Sample preparation should cover the factors bearing on color discussed earlier: alloy, surface preparation, process, coating thickness and weight. Geometrical considerations, such as the contour of the final part and the kind of light to which it will be exposed, are important too.

Organic or inorganic pigmentation may be used, but they differ in light stability: Organic dyestuffs vary more widely in their light fastness than do the inorganic, or mineral types. But the mineral colorants are more limited in color range–only shades of black, brown, gold, yellow and blue being possible. Further, the mineral

Table IV—11 Basic Tests for Coating Quality

Thickness	ASTM B110-45 ASTM B244-49T
Weight	ASTM B137-45
Corrosion resistance	ASTM B117-54T (Neutral salt spray) ASTM B287-54 (Acid-modified salt spray) Humidity chamber tests
Quality of seal	ASTM B136-45 Kesternick Test (European, SO_2-humidity) Sodium chloride-cupric nitric immersion
Abrasion resistance	Abrasimeter (air-blast or rotating wheel)
Color durability	Weather-ometer or fadometer

Table V—Thickness and Weight Specifications for 10 Common Coatings

DESIGNATOR		THICKNESS		COATING WEIGHT, MG/SQ IN.			
				Wrought Alloys		Cast Alloys	
Alcoa Number		Minimum Thickness, Mils	Rating, Amp.-Min.	1100, 3003, 5052, 6061 and 6063	2014 and 2024	43, A214, F214, 319, 355 and 356	A108, 112, 333, 113, 195 and B195
Wrought	Cast						
200	–	0.15	120	8	3	–	–
201	701	0.22	180	10	5	8	–
202	702	0.30	240	14	7	12	–
203	–	0.35	300	17	10	–	–
204	704	0.45	300	21	11	16	10
214	714	0.60	540	30	–	26	–
211	–	0.80	720	40	–	–	–
215	–	0.90	720	40	17	–	–
225	725	1.00	720	43	33	45	40
226	726	2.00	1440	86	66	105	70

pigmentation processes are more complex and require more careful control to get stable and uniform colors. The main consideration in choosing between the two types is the environment involved.

Table VI—Minimum Thicknesses for 7 Environments

Environment	Typical Applications	Thickness, mils	Weight, mg/sq in.
Interior (no abrasion)	Appliances	0.15	7
Interior (slight abrasion)	Architectural	0.20	10
Exterior (maintained)	Auto trim	0.15–0.30	7–13
Interior (avg. abrasion)	Architectural	0.4	17
Exterior (not maintained)	Architectural	0.7	32
Interior (high abrasion)	Architectural	0.8	35
Maximum abrasion	Sliding parts	1–2	33–105

A TYPICAL SPECIFICATION SHOWS THE WAY

The Problem: A large instrument panel on a kitchen appliance has been designed as an aluminum stamping with a lustrous, colored anodized finish. Panel is flat, must be stiff enough to carry instrument weights and operator finger pressures. Here is a rough specification for an anodized coating to meet job requirements.

For These Factors	These Specifications	Meet These Requirements
1. Alloy (from Table I & see text, p. 44)	Aluminum alloy 5457 or 5557; one side bright, mill finish	Max. lustre; structural strength; color reproducibility without alloy tints
2. Pre-treatment (from Tables II & III, and see text, p. 46)	Finish before anodizing: 1. A2 buff 2. R5 brighten or electrobrighten	Max. lustre and smoothness
3. Coating type (see curves and text, p. 49)	Dilute sulfuric acid, approx. 15% by wt. at 72°F.	Max. lustre and bright color; good abrasion and corrosion resistance
4. Coating thickness and weight (from Tables V & VI, and see text, p. 51)	Alumalite 200 coating: Min. thickness 0.15 mils, Min. weight 7 mg./sq. in., at 120 amp.-min.	Abrasion resistance for "average interior" conditions (mild abrasion)
5. Color (see text, p. 50; also see Editor's Note)	Aquagreen: color to be within range of shades shown by control samples viewed in bright, diffuse polychromatic light	Soft restful green, controlled in production so mating parts match
6. Sealing (see text, p. 51)	Seal final coating	Non-staining coating with good corrosion resistance
7. Tests (from Table IV)	Inspect 1 of every 1000 parts: Thickness: ASTM B244-49T Weight: ASTM B137-45 Seal: ASTM B136-45 Color: Control samples	Appropriate tests to assure minimum coating properties are met

SEALING THE COATING

Even after absorption of colorant into the pores, the coating is still adsorbent; various substances will stain the coating and lower corrosion resistance. Most common method of sealing the pores is simple immersion in boiling water, with hydrolizing compounds added for colored coatings to set the color and seal the coating. For maximum corrosion resistance, use inhibitors like boiling dichromate solutions or dilute chromic acid solutions—though these tend to give the coating a yellowish tinge. Sealing is a part of the process, but it may be necessary to specify tests to find out whether the coating is completely sealed. Table IV lists appropriate tests.

Not all anodic coatings are sealed, as some functional applications don't require it. Hard anodic coatings, for example, are never sealed since abrasion resistance is lowered. Some anodized parts must work in sliding contact, so unsealed surfaces have an advantage in lubricant retention.

HOW MUCH COATING?

A correctly designed specification should pin down the thickness of anodic coating desired, along with its density or weight. Thickness is fixed indirectly by specifying a combination of the two process factors that influence coating thickness most—coating time and current density. Multiplying these two gives the single, commonly-used, 'ampere-minute' rating. Table V shows the ratings for 12 anodizing treatments covering the full range of thicknesses. Listed with each rating is the minimum thickness to be expected, along with the density of the coating in milligrams/sq in.—for both wrought and cast alloys. The properly drawn specification, then, contains all three items drawn from this table: ampere-minutes, minimum thickness, and coating weight. Suitable combinations of minimum thickness and weight for the common operating environments are shown in Table VI.

For REPRINT of above article, just check P9 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Other recent articles on colored finishes for aluminum products include:

Porcelainized Cast Aluminum, Aug 17 '59, p 47. Latest data on low-temperature frits for permanent mold castings may soon apply to die-cast parts. Staff report covers properties, colors and design limitations of new series.

Color and Textures for Aluminum, Sept 30 '57, p 101, discusses several surface treatments—mechanical, chemical, and electrochemical—plus some coloring methods peculiar to aluminum.

Prefinished Aluminum, Apr '56, p 135, shows how electrochemical, paint, and electroplated finishes withstand forming; describes mill products available in prefinished chemical colors.

Two recent articles covering the problems of coloring steel products are:

Textured Steel, Mar 17 '58, p 73. Staff report shows when to use it, how it's made, where it's applied—in addition to tips on design and fabrication and two new color processes.

Pre-Painted Steel, Dec 9 '57, p 99. Staff report shows when and how to specify this colorful, functional and economical material.

what fillers will do for the **LATEST TEFLON**

Like the older fluorocarbon resins, the copolymer type designated Teflon 100X works better in some applications when it's reinforced. Here's latest design showing how to get the most out of this new thermoplastic.

W B WATKINS, *product technologist*
Polychemicals Department
E I duPont de Nemours

When the Teflon family's new member, 100X, is introduced commercially this fall, there will be some structural applications requiring more stiffness and wear resistance than the resin inherently has. As with the older Teflon, the answer for the newcomer will lie in reinforcing with appropriate fillers.

But which filler to choose? To help with selection, this article compares 6 basic reinforced varieties of 100X, and shows how to compute their mechanical properties at elevated temperatures.

Main influence of the fillers is on material properties, as shown in accompanying tables. Secondary but also important is the reduction of mold shrinkage—by as much as 50% over unfilled resin, when the mixture is 10% Fiberglas. This, plus easier fabrication of the new resins generally, means metal parts can be encapsulated easily without fear of thermal cracking during service—since residual stresses in the coating are low. Examples are electronic components and valves for chemical service.

What the Tables Tell

How temperature affects short-time mechanical properties can be determined from Tables I and II. Tensile strength, tensile modulus and flexure modulus change a constant percentage, compared with unfilled values, over a fairly wide temperature range. Parenthetical numbers in Table I show the change ratio for each filler addition. Thus, to compute the tensile strength

What Is Teflon 100X?

Teflon 100X FEP-fluorocarbon resin is a fluorinated ethylene-propylene polymer produced by combining tetrafluorethylene and hexafluoropropylene. In properties, 100X is very similar to the older Teflon-TFE; however the 100X resin, unlike TFE types, can be molded and extruded pretty much like other thermoplastics. The new resin shares the physical, electrical and thermal properties of TFE resins in continuous service up to 400 F, compared to 500 F for TFE resins. When fillers are added, some of these properties suffer and others gain as these tables show. Filled 100X can be compression- and injection-molded, but extruded only at slow rates. Pressure-bonding to metals and other substrates is possible with both filled and unfilled 100X. Typical conditions: 300 psi, 550 F for 1 to 2 min., giving peel strength of from 5 to 10 psi.

Table I—Mechanical Properties at Room Temperature

Figures in parentheses are ratios giving comparison with unfilled 100X. Flex life is from MIT flex test; crack resistance is from accelerated test per 1958 ASTM Standards, Appendix 1.

Filler	Filler Content, % wt	Tensile Strength, psi x 1000	Tensile Modulus, psi x 1000	Flexure Modulus, psi x 1000	Tensile Impact, ft-lb/cu in.	Flex* Life, % unfilled	Crack** Resistance, % unfilled
Unfilled....	0	3290 (1)	70 (1)	99 (1)	781	100	100
Fiberglas...	10	2310 (0.8)	117 (1.7)	156 (1.5)	568	16	100,000
Fiberglas...	20	2420 (0.9)	171 (2.7)	210 (2.3)	76	2	failed
Silicate fibers	10	1840 (0.7)	94 (1.6)	117 (1.2)	164	1	100,000
Graphite...	10	2190 (0.8)	105 (1.9)	135 (1.4)	216	11	25
Silica.....	10	2390 (0.7)	107 (2.2)	139 (1.6)	484	3	failed
Glass flake.	10	2110 (0.9)	137 (2.1)	170 (1.6)	365	7	25

Table II—Elevated-temperature Properties of Unfilled Resin (Short-time tests)

Temp., °F	Tensile strength, psi	Tensile Modulus, psi x 1000	Flexure Modulus, psi x 1000	Ultimate Elongation, %
−321	16000	487	.....	5
−108	5750	118	.....	40
−65	5420	.....	121	200
73	3290	70	99	320
212	1310	6.5	17	260
392	444	.....	6.8	274

at 212 F for, say, the 10% Fiberglas mixture—multiply the tensile strength of unfilled 100X at 212 F (1310 psi from Table II) by the listed change ratio for the same material (0.8 from Table I). Resulting tensile strength is 1048 psi. This method applies to tensile strength and flexure modulus from −65 F to 392 F; for tensile modulus, from 73 F to 212 F.

Prolonged heat-aging has no effect on tensile strength. Elongation, however, suffers a sharp drop, Table II, with all except the 10%-Fiberglas additive and the unfilled material. As might be expected, mixtures using the particle fillers do not retain their ductility after aging as well as those with fibrous reinforcement, but the unfilled resin suffers little change. Thus if the extra stiffness provided by fibrous filler is not needed, consistent deformation response can be expected from the unfilled resin.

Short-time stress-relaxation tests are a tentative indication of a material's creep behavior. Measurements from compression relaxation tests, Table IV, suggest that fillers do not greatly improve creep performance of Teflon 100X. At high temperatures the greatest stress-retention occurs, particularly with the graphite addition. Long-term creep measurements on these materials are being made.

Bearing wear is markedly improved by filler addition, Table V, particularly with the Fiberglas. Graphite-filled resin, which shows the lowest dynamic coefficient of friction, has highest wear rate of all. The very low rate for the Fiberglas-filled material is to be expected, based on experience with similarly filled older Teflon types in bearing applications. These data were obtained with dry bearings 0.75 in. ID x 0.95 in. OD x 1 in. long, mounted on a 0.75-in.-dia polished stainless shaft turning at about 1085 rpm. Each bearing was loaded with 15 lb dead weight. Shaft torque measurements gave the friction force at the bearing surface, permitting computation of dynamic coefficient.

Electrical properties of filled Teflon 100X, Table VI, are inferior to unfilled resin, although satisfactory for the majority of industrial applications. Fiberglas compositions, which show the best property balance considering all the tests described here, also exhibit the best retention of electrical characteristics. This, plus low mold shrinkage and high rigidity, makes Fiberglas-filled Teflon 100X a good candidate for electrical applications such as tube sockets and connectors—especially where elevated temperatures are met. Electrical tests on mixtures containing powdered copper show that at about 20% Cu the resin becomes semiconductive.

EDITOR'S NOTE: Check these articles on reinforced plastics: **Three New Epoxies Join the Pre-preg Laminates,** Aug 31 '59, p 38—data on a new family for high temperatures.
Filament Winding Grows Up, July 20 '59, p 46—new high-speed process is ready for non-aircraft applications.
What's New About the New Papers?, Feb 16 '59, p 61—data on how new treatments and fibers improve properties.

Table III—How Heat-aging Affects Ductility (Aged in air at 464 F)

Filler	Ultimate Elongation, %, after 0 hr	2 hr	24 hr	100 hr	300 hr	1000 hr
Unfilled	320	310	270	380	340	380
10% Fiberglas	220	140	170	220	230	206
20% Fiberglas	24	13	11	10	13	15
10% Silicate fibers	86	57	29	45	74	63
10% Graphite	68	25	20	49	21	6
10% Silica	41	29	24	7	17	6
10% Glass flake	70	27	19	69	75	2

Table IV—Compressive Stress-relaxation vs Temperature

Filler	Percent of initial stress, S, remaining after 10 hr at 73 F (S = 1000 psi)	392 F (S = 60 psi)
Unfilled	79	15
10% Fiberglas	71	23
20% Fiberglas	80	22
10% Silicate fiber	72	26
10% Graphite	83	30
10% Silica	68	16
10% Glass flake	80	23

Table V—Bearing Wear Tests

Filler	Wear Rate, (cc/million cm travel) x 10^{-5}	Dynamic Coefficient of Friction
Unfilled	740	0.67
10% Fiberglas	0.25	0.47
20% Fiberglas	0.34	0.47
10% Silicate fiber	0.55	0.57
10% Graphite	23	0.39
10% Silica	9.5	0.50
10% Glass flake	0.91	0.49

Table VI—Electrical Properties

Filler	Dielectric Constant	Dissipation Factor	Dielectric Strength, v/mil
Unfilled	2.08	0.000,2	1360
10% Fiberglas	2.26	0.000,5	1225
20% Fiberglas	2.48	0.000,7	1153
10% Silicate fibers	2.28	0.002,2	600
10% Graphite	3.19	0.001,4	268
10% Silica	2.24	0.002,3	1328
10% Glass flake	2.67	0.086,0	1263

13 ways to cut
DRAFTING COSTS

Check this list of modern methods and materials compiled by an expert in drafting-room procedures.

A F GAGNE, *Consultant*
Binghamton, NY.

To reduce drafting time: **Don't draw unnecessary lines.** One approach, the "Simplified Drafting method, omits all lines that have no importance to shop personnel. But if carried too far, the time saved in drafting may be swallowed up in production. A better method is to avoid drawing lines when they can be printed, traced, stamped, constructed with a machine, or otherwise mechanically applied. Here are the tools available today. Are you using them?

1 Preprint all repetitive material. Provide cut-to-size, pre-printed forms in all common sizes. They save lettering title blocks and drawing borders, and get rid of odd-size tracings. Stock forms can be purchased for not much more than cost of paper in rolls.

Parts of the drawing itself can even be preprinted. Optional material can be printed in non-reproducing blue lines, and traced as needed. Wiring and pneumatic diagrams, chassis with different hole layouts, studs, spacers, cams and springs can be printed in black for the draftsman to complete by filling in. This saves time in checking as well as in drafting.

2 Prepare tracing templets for common components. A file of standard component drawings or assemblies, suitable for tracing, are cheap to prepare. An increasing number of component suppliers offer tracing templets of their products to customers. But you can make your own. A file of full, half and quarter-scale drawings of proprietary parts and components will save drafting time when the assembled product has many standard parts. Ingersoll-Rand Co, for example, estimates that the templet file in their Machine Assembly Section saves 30 percent in drafting time.

3 Supply rubber stamps and self-adhesive appliques for frequently drawn symbols and diagrams. Rubber stamps are popular for applying title blocks and standard notes but have four limitations: drying time, uncertain quality, gray lines and uncertain positioning. New inks and pads help solve the first two problems, while the recently introduced stamps made of transparent rubber and plastic have overcome the positioning difficulty.

Appliques, those transparent, pressure-sensitive drawing aids, are also useful. Standard symbolic components and custom forms (hole or drilling patterns, mechanical components, special notes or warnings, title blocks) can be purchased in strips or rolls at nominal cost compared to equivalent drafting time. Some firms are completely sold on them; others find that adhesives sometimes bleed, picking up dirt, or that they separate, wrinkle, or leave heavy "ghost" backgrounds when several generations of intermediates are made. This will not be a problem when tracings are microfilmed or otherwise reproduced in a manner that does not depend on light passing through the paper.

4 Templets do a uniform job. When a symbol consists of but a few simple lines, the cutout or stencil templet is faster than the appliques or any of the tracing methods. They are inexpensive and make short work of squares, circles, ellipses and such specialties as fluid fittings drawn to precise scale. It may seem that such painstaking delineation is a waste of time, no matter how speeded up. But careful component layouts provide visual guarantees against interference—important as equipment becomes more complex, more compact.

Leroy, Variograph or Wrico scriber templets are inherently faster than cut-out templets because no shifting is required to create a complex symbol. But, they are limited in the size of character that can be made.

5 New pens and pencils solve some long-standing problems for the draftsman. Pencils sharpened with pen knife and file (or sandpaper block) can cost as much as $75 per man-year according to a time check made by the author. Instead, provide manual and electric rotary sharpening devices, vibrating sandpaper blocks (good for compasses as well as pencils) or mechanical pencils with thin leads that need no sharpening (recommended for a series of long lines, rather than for detail work). Also, an electric eraser can easily save fifteen minutes per day, returning purchase cost (around $22) in one month.

Push-button ruling pens refilled from a cartridge in the handle, and wide-blade pens hold more ink and are less apt to run dry at the wrong time. There are also special fountain pens and spring-leaf brushes that provide constant-width lines for hand lettering.

6 Take advantage of recent developments in drafting paper. The cost of drafting paper is negligible when compared to the value of the drawing after it has been prepared. Therefore, don't buy inexpensive paper; instead look for those qualities that reduce drafting effort.

If, for example, a harder pencil can be used without gouging, embossing, or reducing contrast between line

Your Shopping Guide ... a representative list of suppliers for the time-saving tools listed in this article

Appliques

Aplica Co, Greenwich, Conn
Chart-Pak Inc, Leeds, Mass
F Ward Harman Assoc, Halesite, NY
H G Daniels Co, Los Angeles 17
Keuffel & Esser Co, Hoboken, NJ
Para-Tone Inc, LaGrange, Ill
Stanpat Co, Whitestone 57, NY

Thin lead pencils (no sharpening required)

Alvin & Co, Windsor, Conn ("Constructor" drawing pencil with lead 0.016 x 0.047)
A W Faber-Castell Pencil Co, Newark 4, NJ ("Locktite Fleetline 9600" with lead 0.017 x 0.097)

Easy-shift drafting boards

Emmert Mfg Co, Waynesboro, Penna
General Fireproofing Co, Youngstown 1, Ohio
Hamilton Mfg Co, Two River, Wisc
L.A.B. Corp, Skaneateles, NY
Mayline Co Inc, Sheboygen, Wisc
Nestler Corp, Pittsburgh 22
Stacor Equipment Co, Brooklyn 3, NY
Fredrick Post Co, Chicago 18

Track-type drafting machines

Charles Bruning Co Inc, Mount Prospect, Ill
Emmert Mfg Co, Waynesboro, Penna
Glideline Corp, Waynesboro, Penna
Keuffel & Esser Co, Hoboken, NJ
Universal Drafting Machine Corp, Cleveland 2

Lead sharpeners

Manual: small, blade-type ($1.25 up)
- Alvin & Co, Windsor, Conn
- Theo Alteneder & Sons, Philadelphia
- Koh-i-noor Pencil Co Inc, Bloomsburg, NJ

Sandpaper-cup type ($2.95)
- Elward Mfg Co, Colonia, Mich ("Tru-Point")

Automatic
- Charles Bruning Co Inc, Mount Prospect, Ill (pointer attachment for eraser, $1.75)
- Ferance Construction Co, Penfield, NY (vibrating file, $12.95)
- Johnson Mfg Co Inc, Monroeville, Ind ("Point-O-Matic" spinning file, $14.95)
- Stile-Craft Mfgrs Inc, St Louis 10, Mo (sharpens wood pencils also)

Stencil templets (standard and to-order)

Alvin & Co, Windsor, Conn
Dalgonkov Mfg Co, Detroit 2
E F Twomey Co, Los Angeles 15
E-Z-Way Templates, Reseda, Calif
John R Cassell Co Inc, New York 18
Keuffel & Esser Co, Hoboken, NJ
Rapidesign Inc, Box 592, Glendale, Calif
Timely Products Co, Basil, Ohio
Wood-Regan Instrument Co Inc, Nutley, NJ

Drawing Pens

Keuffel & Esser Co, Hoboken, NJ (Marathon ruling pen)
Koh-i-noor Pencil Co Inc, Bloomsburg, NJ (Rapidograph Technical fountain pen, $4.50)
Ozalid Div, Johnson City, NY (distributors of Reifler "Grafika" Pen sets, $25.75 up)
Rule-O-Matic Corp, New York 22 (ruling pen)
Howard C Hunt Pen Co, Camden, NJ (steel brush)

Dotting Pens

Charles Bruning Co Inc, Mount Prospect, Ill.

Ellipse and Perspective Drawing Devices

Charles Bruning Co Inc, Mount Prospect, Ill (Circular Drawing Machine, $125, and Perspec-O-metric attachment, $40)
A Partrick Co, Westwood, NJ (Omicron Ellipsograph, $12)
Indamer Corp, New York 18, NY (Vibax Isometric and Dimetric Drafting Machine, $175)
Frederick Post Co, Chicago 18

Tracing Equipment

Hamilton Mfg Co, Two Rivers, Wisc
Ozalid Div, Johnson City, NY
Porta-Trace Inc, Binghamton, NY
Stacor Equipment Co, Brooklyn 3, NY

Cross-Hatching Devices

Koh-i-noor Pencil Co Inc, Bloomsburg, NJ ("Kohliner" push-button device)
Nestler Corp, Pittsburgh 22 (arm-type drafting machine has push-button hatching attachment)

Art Projectors

J A Engel Inc, Minneapolis 14, Minn (Art-O-Graph)
Lacey-Luci Products Co, Newark 2, NJ
Trace-Rite Sales Corp, Detroit 2

and background, there will be fewer stops for pencil sharpening and tracings will be cleaner, sharper, and probably more accurate. Other points: does the material take pencil or ink well after erasing; does it pucker after erasure or when humidity changes; is it sufficiently transparent for good prints; will it resist tears and wrinkles.

Some of the new polyester films such as DuPont's "Cronaflex" score outstandingly on all counts. They are unusually transparent; a 6H pencil produces an intense line that can be speedily erased; they are virtually indestructible, with none of the tears, rips and dog-earing so often experienced with vellum. A film thickness of four mils is suggested to prevent embossing by hard pencils. Cost is around 21¢/sq ft in quantity.

7 Use intermediates to save tracing time. These "reproducible reproductions" will restore worn-out tracings, generate duplicate "originals" for more economical printing, and facilitate engineering change and redesign. This last application is one of the most valuable and perhaps the least common. With intermediates, drawings are edited, not redrawn or traced. Unwanted areas are masked out when the intermediate is printed. Lines are erased by chemical or mechanical means (or, if a

negative intermediate, by rapidly brushing a special opaque paint over undesired portions). New drawings are composed from scissored pieces of old drawings.

8 Specify photographs in place of drawings. This is especially useful for showing changes in existing equipment; these are marked over a photoprint. Other applications: assembly drawings, diagrams for instruction manuals, exploded views of complex mechanisms. Because the camera does not have a discriminating eye, distracting backgrounds must be minimized.

9 Tell draftsman how accurate the drawing needs to be. There are a number of occasions when an accurate, mechanical drawing is unnecessary and a freehand sketch will be quite adequate. On the other hand, special parts can sometimes be prepared by making very precise, full-scale drawings and printing directly on the surface of the metal. Thus, one precise layout in drafting saves many layouts in the shop.

10 Provide a comfortable, efficient environment. If you can afford posture chairs for the secretaries and the factory girls, get good chairs for the much better-paid draftsmen. The board is also important. With the new, fast-adjusting board, the work is always at the right angle and the right height. Easy-shift boards not only make substantial contribution to output, drawing quality, appearance of drafting room and morale, but can save up to 40% in floorspace.

11 Typewriters are faster, cleaner than lettering pens. Special purpose typewriters or conventional typewriters with long carriages are faster and neater than other methods for those long lists of materials, specifications, notes and instructions. But all too often, these parts of the drawings are hand-lettered because the firm doesn't think it can afford a special machine. This is not good reasoning: the cost of the machine is small compared to the cost of equivalent drafting time.

Another easy job often done the hard way is drawing guide lines for lettering. This can be accomplished with a cross-section backing sheet under the drawing, such as K & E's Laminene board covering, or by providing drawing paper that has non-reproducing cross-hatch lines.

12 Drafting machine does the job of straightedge, scale, protractor, triangles. Combining these tools, comfortably in the left hand can save 10 to 50% in drafting time. The new X-Y track-type machines overcome many of the objections to the steel band or linkage-controlled machines. First-cost, habit, and training time are other problems each firm must evaluate for itself. For those who prefer to stick with the string-type parallel rule (recently improved with ball bearings) a triangle is recommended that has a knob for lifting and stencil cut-outs for symbols and machine elements.

13 Special tools make short work of special jobs. Ellipsographs, "circular drawing machines" and templets do away with classical methods of constructing ellipses. Other 3-D devices include semi-automatic machines for perspective rendering and specially ruled paper.

Art projectors are, unfortunately, little known outside the art department. But they have many applications in the drafting room. Photographs, small drawings or parts can be traced on the spot, without distortion or lost time. Price is around $430.

Light boxes are a time saver when tracing poor prints, comparing details with assemblies, or checking interferences through several layers of tracing paper. Other uses include inspection of transparencies and X-rays, and stripping-in and opaquing of negatives. Compared to tracing tables, portable light boxes will not occupy space in the drafting room, can be stored like a book and conveniently brought to the user's board when needed. Prices start at about $32.50.

Another gadget is the cross-hatcher. It permits faster and better-appearing work than cross-hatching positioned by eye. Some are built into the drafting machine (Nestler); others are a separate piece of equipment to be used with parallel rule or drafting machine. Also consider having such time-and-work savers as adjustable curves, proportional dividers, dotting pens, double-line pens, quick adjusting compasses.

The author wishes to thank Charles MacArthur (Dataflow, Inc.) and others who generously provided comment and criticism.

for REPRINT of above article, just check p8 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Reducing drafting time and cost is an area of continuing study and innovation. Some experts recommend simplified drafting; others suggest shortcut techniques, or faster, more efficient tools. Here are the most recent articles:

DRAFTING COSTS

Drafting Costs Going Up, June '57, p 166, a point-by-point comparison between drafting costs of 1935 and 1957.

Measuring Drafting Costs by the Square Foot, Aug 31 '59, p 22, a method of estimating drawing cost from its size.

SIMPLIFIED DRAFTING

Simplified Drafting—Pro and Con, July '56, p 200, two experts express opposing views on a controversial question.

Drafting Procedures Should be Standardized Rather than Simplified, Aug '55, p 162, a seventeen-point comparison and tabulation of three drafting methods.

Functional Drafting . . . Another Viewpoint, Feb '57, p 100, a time-saving method that doesn't eschew conventional notation or cause confusion.

METHODS AND EQUIPMENT

Reducing Costs in the Drafting Room, June '55, p 193, nine tips and tools that save money.

Combined Techniques Cut Drafting Time, Tedium, Dec 22 '58, p 25, a report on American Bosch Arma's Fotogram system—an ingenious bag of photographic tricks that save many drafting steps.

Painless Drawing Changes, Sept 14 '59, p 83, an organization set-up that makes clerks, not engineers, responsible for drawing changes.

Choosing Equipment for Drawing Reproduction, Jan '57, p 135, an evaluation of various kinds of copying equipment.

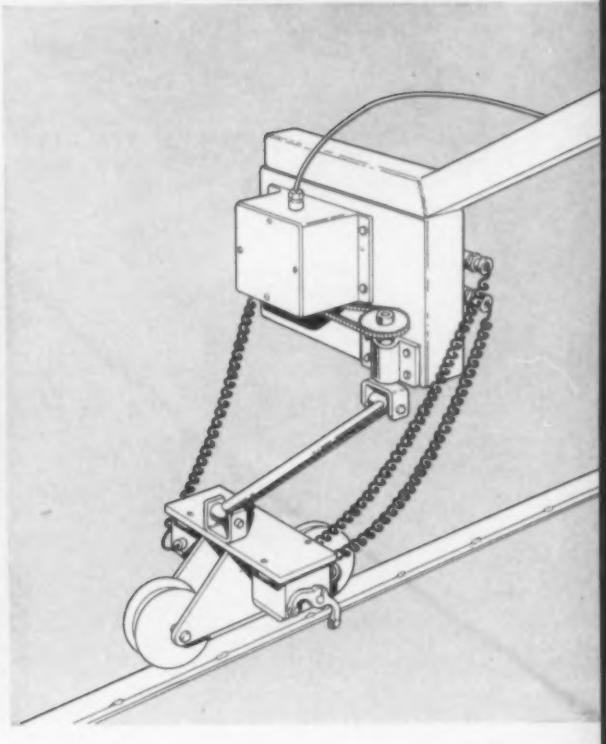
For Today's Draftsman, These Modern Tools, Oct 13 '58, p 68, a rundown on the equipment that will bring your drafting room up to date.

Microfilm Pushes Drawings Aside, Oct 27 '58, p 94, a case study of an active microfilm file.

Missile Launcher Steers Self to Exact Spot

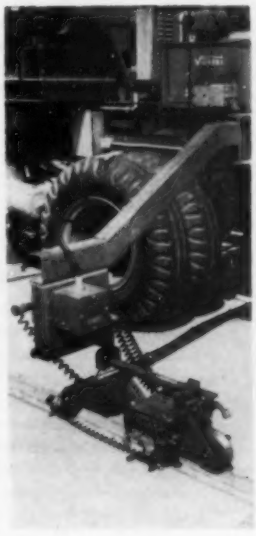
This service tower is automatically controlled by an arm following a lightweight guide rail, yet retains freedom to maneuver while erecting the missile.

When servicing a missile the tower is supported on eight 30-ton jacks that automatically level the structure. It is carried by two trailers rolling on 24 heavy-duty tires. In contrast with such towers mounted on steel rails, this self-driven version provides maneuverability required for precisely aligning a satellite shot. The automatic steering is electro-hydraulic, rapid and accurate. The 150-ft tower can be disassembled after a launching—it breaks down to 13 loads for transport by air or over the road. Its electric controls are produced by Rundel Electric Co, Milibrae, Calif; the tower itself, by The Noble Co, Oakland, Calif.



Follower arm . . .

is guided by a light rail that can be laid down or easily moved elsewhere for another shot, and connected by roller chain and sprocket to a pair of primary potentiometers. Mounted on each steering axle is a feedback potentiometer connected to the king pin by roller chain and sprocket.



Any departure from the course set by a guide rail changes resistance in the primary potentiometers. This unbalances the armature of a pair of servovalves, admitting high-pressure oil to the hydraulic steering rams. As the steerable wheels respond, the feedback potentiometers restore the balance of the circuit; then, when electric balance is achieved, motion of the wheels stops. As the vehicle returns to the established course the primary potentiometers return to their initial position and the wheels straighten up on center.

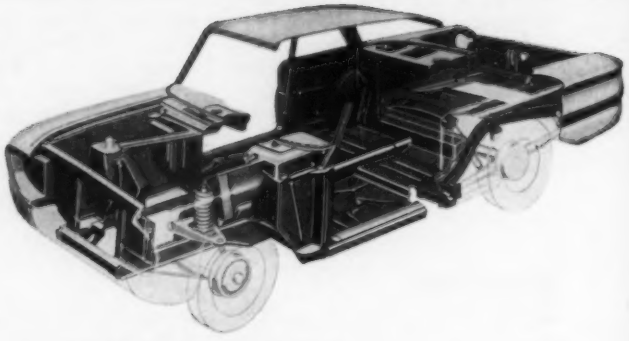
Since the two trailers are 31 ft apart, compensation is provided for difference in turning radius. The feedback potentiometer on each trailer has five taps on each side of neutral and connected to trimmer potentiometer. Adjusting these trimmers allows selecting any required difference in angle of turn of the two pairs of steerable wheels.

PRODUCT DESIGNS: FIRST OF THE BIG THREE'S

FORD'S

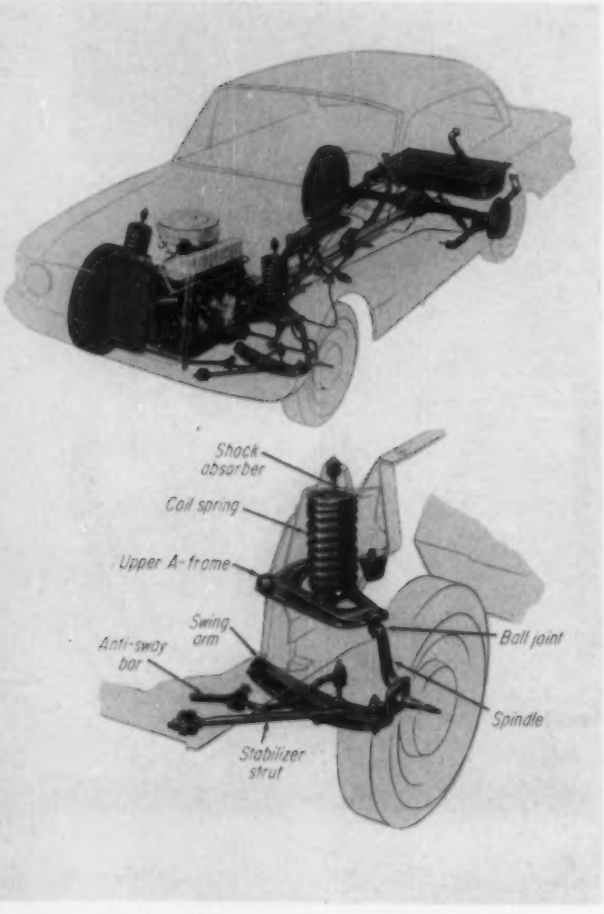
Henry Ford would have approved the lighter weight and lowered cost of this model. Along with its unitized body and simplified construction, it has a simple 6-cyl engine for economy and easier maintenance. General Motors and Chrysler also are answering the foreign imports with a smaller car—their candidates will be analyzed in forthcoming issues.

First to appear of the competitive three, Falcon sedans (2- or 4-door) avoid any spectacular innovations but incorporate many well-tried features to accomplish their goal. A great deal smaller than the much-criticized family-size sedans of recent years, Falcon still provides more room than the typical European small car. Produced by Ford Motor Co, Dearborn, Mich.



One-piece body frame . . .

is just that—one unit incorporating frame, body, engine mounts, and suspension-attachment points into a single weldment. This construction eliminates many possible sources of rattles and squeaks, provides a rigid, lightweight structure. Fenders are separate bolt-on assemblies that can be easily removed for repair.

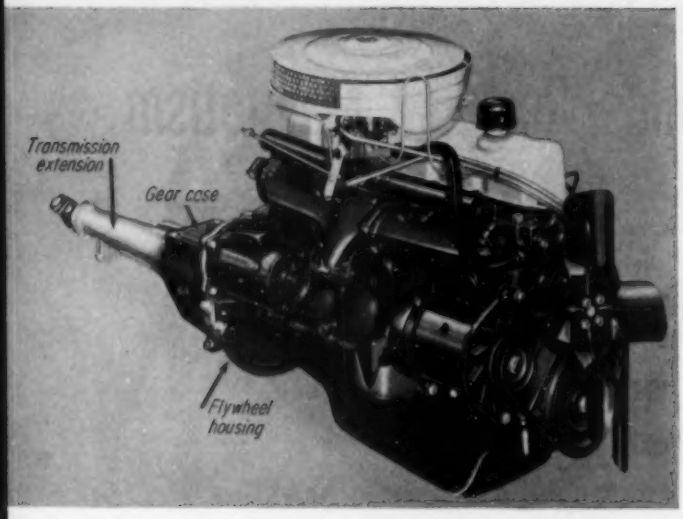


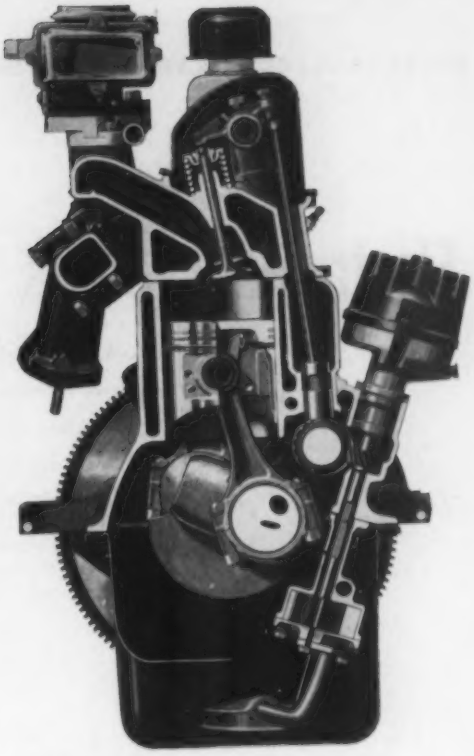
Running gear . . .

uses double A-frames and coilspring at the front, and longitudinal leaf springs at rear. Power to rear axle is transmitted by open driveshaft incorporating two universal joints.

Most noticeable difference in suspension is mounting of the coil spring and shock absorber on the upper A-frame. Upper end of the coil spring and shock absorber are retained in a sheetmetal tower that projects into the engine compartment and is integral with the body-frame weldment. The lower A-frame consists of a lower arm and trailing stabilizer strut. The lower arm guides lower end of the wheel spindle through vertical motion while the stabilizer strut absorbs horizontal forces. The anti-sway bar interconnects left and right lower arms to reduce body roll on turns.

FALCON





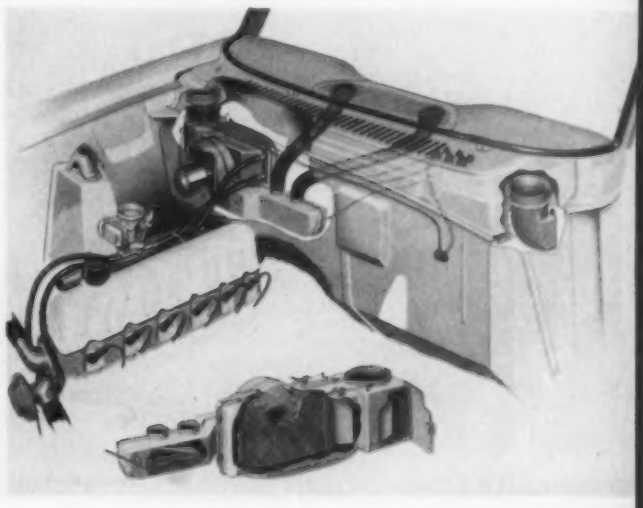
Engine block and head . . .

are cast iron despite widespread industry interest in aluminum engines. A difficult weight goal was achieved by simplicity and reduction in the number of parts needed. Aluminum is used for the flywheel housing and transmission extension. Between them is a cast iron gearcase.

Cylinder head incorporates the complete intake manifold and the valve stems run directly in the block, eliminating need for separate valve guides. High-pressure lubrication is provided by a pump mounted on lower end of the distributor driveshaft. Both pump and distributor are driven by spiral bevel gears mounted on the camshaft.

QUICK LOOK AT FALCON'S 4-DOOR SEDAN

Over-all length	181.1 in.
Over-all height	54.5 in.
Over-all width	70.0 in.
Weight (dry)	2320 lb.
Tread, front	55.0 in.
rear	54.5 in.
No. of cylinders	6
Bore & Stroke	3.5 x 2.5 in.
Displacement	144.3 cu in.
Compression ratio	8.7 to 1
Torque, lb-ft	138 @ 2000 rpm
Brake-horsepower	90 @ 4200 rpm
Tire size—tubeless	6.00 x 13
Brake area	114.3 sq in.
Turning dia	37.7 ft.
Water capacity	8.7 qt
Electrical System	12 volts
Fuel-tank capacity	14 gal.



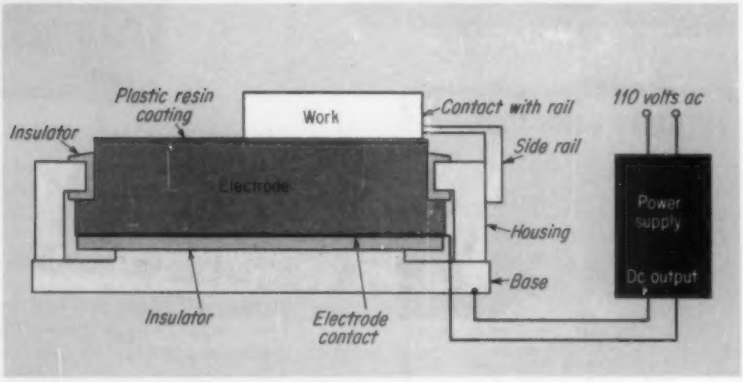
Cowl ventilator . . .

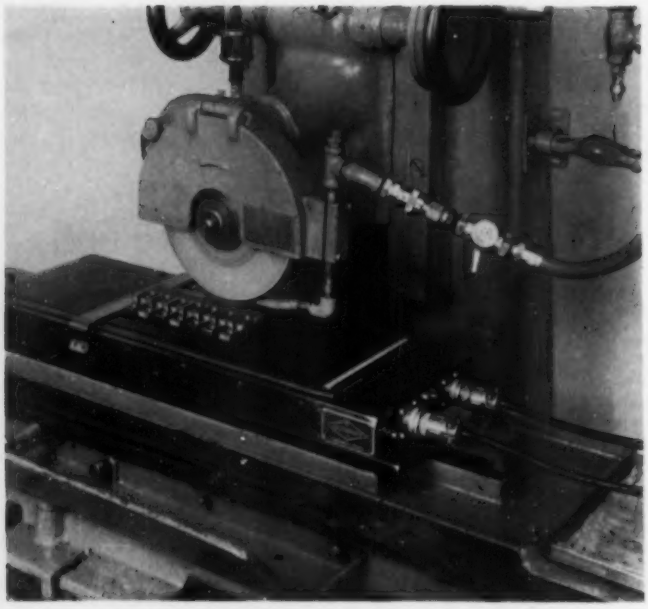
provides air for the low-cost heater-defroster. It controls air temperature by mixing outside air with air from the heater core. This method eliminates the valve usually used to control water flow through the core. Varying the position of the temperature-control door changes ratio of the two air supplies. A 2-speed blower provides forced draft for heating and defrosting. Warm air for defrosting is delivered to the combined radio-defroster grille where fixed vanes direct it over the windshield.

Electrostatic Chuck Avoids Residual Magnetism

Chuck effectively holds any electrically conductive material. Nonmetals such as ceramics, glass or plastics can be held, too, if they are flashed with a metal coating.

Chuck shown may be used on a surface grinder 6 x 18 in. or larger. The renewable, hard-resinoid, work-holding surface is easily dressed to precise limits. Complete chucking system includes the chuck, power supply, "dri-box" and a dielectric filter for coolant. Produced by Electroforce Inc, Fairfield, Conn.

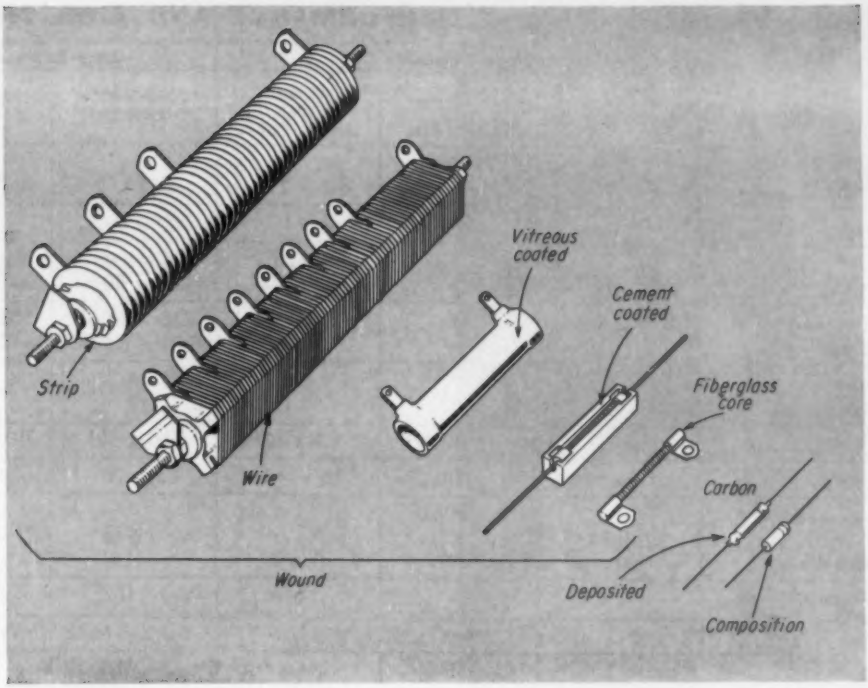




Static electric charge . . . rather than electromagnetic force is used here to hold the work rigidly; this eliminates the problem of residual magnetism that arises with ferromagnetic materials. The electric charge is placed on the surface of the workpiece, which is electrically isolated from the face of the chuck by a thin dielectric coating.

A film of dielectric liquid is spread on the chuck before the workpieces are positioned. Electrical ground connections to the work are provided by simple connection strips. To help retain the charge, cleaned workpieces are dried by placing them in an electrically warmed box a few minutes before loading the chuck.

Chuck is simple in construction. High-voltage dc charge applied across ductile iron housing and electrode produces a static electric charge at contact surface, with a holding force of 30 lb per sq in.



how to choose . . .

FIXED RESISTORS

. . . for power and control

Here is a 3-step selection technique that starts with the load to be carried, and picks the right type and size resistor to handle it.

C T DURHAM, *ceramist, Industry Control Dept, GE Co*

Choosing a resistor for either power or control can be accomplished in three steps—not necessarily simple. First, calculate the resistance needed for the circuit and the power that must be dissipated. Second, pick a resistor type that falls within general requirements of the application. Third, determine exactly what size and design of resistor will work best.

First step needs no explanation because it is just application of Ohm's Law. Yet often overlooked is the fact that a resistor produces heat that must be dissipated. Measured in watts, it equals (current)^2 × (resistance) or (voltage)^2 ÷ (resistance).

Second step is selection of a resistor type from accompanying table, which is in two divisions: high capacity and low capacity. Here are some tips on using the table.

For Heavy Duty

Grid resistors, made from relatively heavy sections of iron or alloys of iron, answer the need for high current capacity with low resistance. They are common in starting circuits for motors over 15 hp.

Cast grids are about 95% iron, the rest carbon and silicon. Although they are brittle and bulkier than punched grids, they have higher resistance per cubic foot and have more mass to absorb heat from sudden loads.

Punched grids are about 80% iron alloyed with chromium and aluminum. They are more flexible, but have lower resistance than cast iron grids.

Wirewound and ribbonwound power resistors cannot compete with grid resistors in high watts dissipation. Wound resistors are available in greater variety than grid resistors.

Vitreous and cement-coated wirewound resistors lead the pack in industrial control circuits. Either of the two coatings helps prevent corrosion caused by atmospheric conditions, and holds wire in place, but the cement coating tends to be somewhat porous. Both types are

REPRINTED circle P7, inside back cover

PERFORMANCE AND APPLICATIONS

	High Capacity			Low Capacity	
	CAST AND PUNCHED GRID	WOUND		COMPOSITION CARBON	DEPOSITED CARBON
		UNINSULATED	VITREOUS OR CEMENT COATED		
Power and current load, watt	up to 6500	125 – 1200	2 – 210	0.2 – 2	0.1 – 2
current, amp	750	100	14	0.6	0.4
Rated temp rise	707 F (375 C)		572 F (300 C)	86 – 176 F (30 – 80 C)	68 – 212 F (20 – 100 C)
Max operating temp (zero load allowed)	–	–	644 F (340 C)	230 – 302 F (110 – 150 C)	248 – 320 F (110 – 150 C)
Resistance, ohm rated: min	0.01	0.03	0.1	3	10
max	10	800	1.8×10^6	100×10^6	100×10^6
tolerance, ±, %	6	10	5 – 10	5 – 20	0.5 – 2
% change caused by: rated temp rise	cast, 24 punched, 6	0 to 9	0 to 9	– 5 to – 15	– 3 to – 7.5
aging (loaded)	–	–	±3 (max)	±10	– 0.9 (max)
voltage	none			±0.3 %/v (max)	very small
humidity	none	slight	none	2 – 10	<2
soldering	none			3 (max)	±0.5
shock	punched, none	none		none	slight
Shape and size, in.	rectangular 12 x 25 x 12	cylinder 2 x 15 (755 w)	cyl., flat, or disk. A 50-w cyl., 0.8 x 4.5	0.2 x 0.6	0.3 x 1
Cost, $	100 – 125	10 – 125	0.30 – 15	0.02 – 0.13	0.11 – 0.65
Applications	motor control		general control	electronics and instruments	military instruments

available in great variety in resistance, size, power rating, terminals, and mounting method.

Silicone-base coatings—a third type—cost less, and can replace vitreous and cement coatings in applications for temperatures below 480 F (250 C).

When the Load is Small

Composition-carbon resistors—resembling a firecracker—outnumber all other resistors. Television and radio applications are the most numerous, but even the Minuteman missile and submerged telephone cables have them. These low-cost resistors are small, have wide range of ratings. However, the stability is poor at high temperatures, therefore full loads are seldom recommended. The example in the table is based on an unsealed design—the most typical. With hermetic sealing, performance characteristics can be improved. For example, resistance change from zero to maximum load can be as small as –2%, and voltage sensitivity as low as –0.05%/v. Humidity does not affect performance.

Deposited-carbon resistors, made by depositing a thin carbon film on a ceramic tube, perform better than a composition-carbon type, but cost double. By adding a small amount of boron to the deposited film, resistance change with load is reduced, but the still higher cost limits it to applications where space and stability are of prime importance.

Precision wirewound resistors are designed to maintain original resistance throughout life despite load and temperature variations. Heating at high temperature during manufacture helps insure this stability. Low inductance designs are made by counter-winding the resistance wire. In operation, power dissipation is kept under rating for best sensitivity. At 50% power, for example, the resistance may be accurate within 0.1%; at 100% power, the variation may increase to 1% due to temperature coefficient of wire.

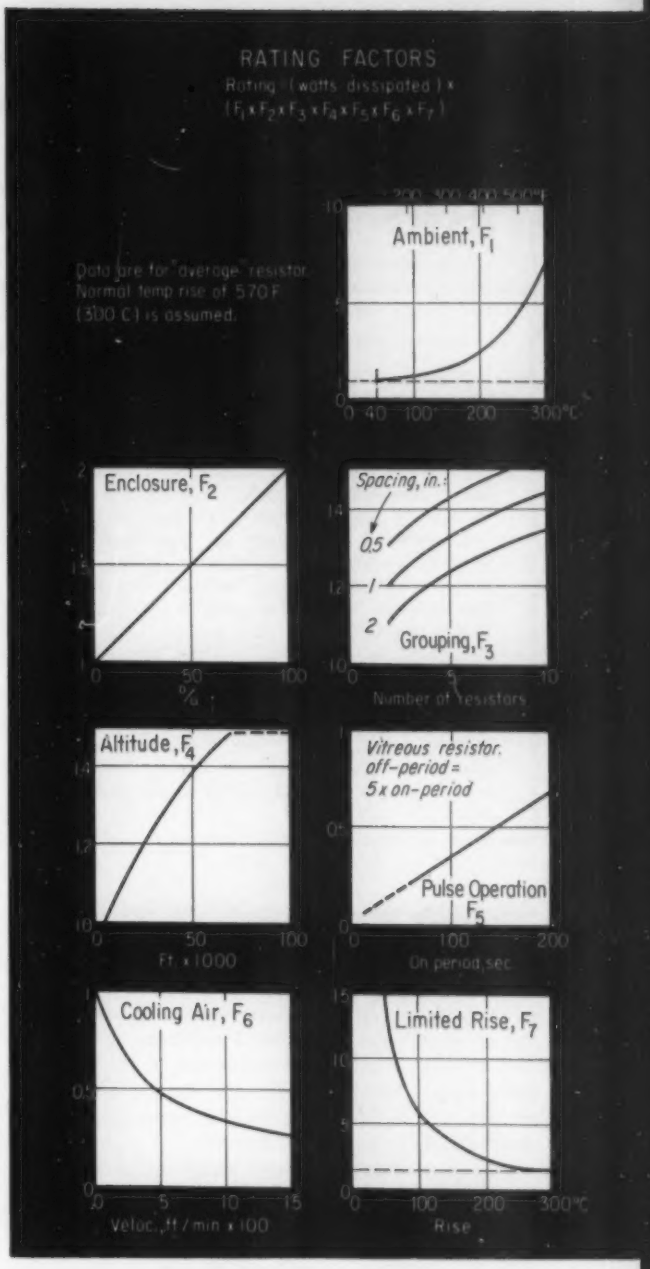
Metal-film type is a fairly recent development. It is small, and has a ceramic base similar to the boron-carbon type, yet has the improved performance of a precision wirewound resistor. Also, operation at higher frequencies is good because inductance is low. Some possible films are nickel-chromium, nickel-titanium, and chromium silicon.

The Rating Method

Third step in selecting a resistor—determining the exact rating—is dependent on the application. So-called "rated load" given in catalogs refers to a hypothetical set of "normal" conditions, rarely achieved. The conditions

FOR RESISTORS (approx. values)

Low Capacity		
DEPOSITED BORON-CARBON	PRECISION WIRE-WOUND	METAL FILM
0.1 — 2	0.1 — 4	0.1 — 2
0.3	very low	0.2
68 — 212 F (20 — 100 C)	59 — 104 F (15 — 40 C)	68 — 176 F (20 — 80 C)
248 — 302 F (120 — 150 C)	221 — 293 F (105 — 145 C)	347 F (175 C)
10	0.1	25
5 x 10^6	20 x 10^6	10 x 10^6
1 — 5	0.1 — 1	0.1 — 1
— 0.5 to — 1.8	±1.4 (max)	±0.3
— 1 to + 2	±0.6	±0.3
very small	none	
<3	none	
±0.5	none	
slight	none	
cylinders — 1 watt		
0.3 x 1	0.5 x 1	0.4 x 1
0.50 — 2.10	1 — 60	0.50 — 3
military instruments		military



are: ambients less than 104 F (40 C); no enclosure; no adjacent heat producers to interfere with natural cooling; low altitude; and full allowable temperature rise. When any of these limitations are exceeded, a larger resistor is selected—to allow for de-rating.

The selection problem is best solved with a simple but approximate equation developed by Ohmite Manufacturing Co, Skokie, Illinois, and published in their recent catalog. It starts with the watts to be dissipated, multiplied by appropriate factors to give needed resistor rating. These factors, plotted on this page for an "average" resistor rated at 570 F (300 C) normal rise, each modify the rating to compensate for non-normal conditions. Here are the reasons:

Ambient temperature above 104 F (40 C). Normal temperature rise from a higher ambient would cause total temperature rise to increase above the allowable value. This is compensated by calling for oversize resistor that meets rating with lower temperature rise.

Enclosure. Almost any enclosure, unless specially designed, will reduce natural cooling effect. So a larger resistor is needed.

Grouping. Adjacent heat-producers cause local hot-spots.

Altitude. Rarified air takes away less heat.

Pulse operation. Short-time load cycling with in-between cooling allows smaller resistor to do job. Curve applies to vitreous resistor only.

Cooling air. Cooling lets smaller resistor do job. See "When Air is the Coolant," Feb 16 '59, p 54.

Limited temperature rise. If other components in the same enclosure have lower temperature limits, then the resistor may have to run cooler to conform. A larger size is therefore required.

What the Future Holds

Within ten years, some predict, most low-capacity resistors will be of two types: composition carbon for

Unusual Ways to Vary Resistance

Most of the resistors in the table can be made adjustable or variable. With taps in most instances; some with slides for control through entire range. Then, of course, there are standard rheostats and potentiometers in great variety.

Less known are the resistors, usually low wattage, that vary by means other than physical positioning of a slide-wire or tap. Here are some:

Temperature

Thermistors have a negative coefficient of resistance—resistance decreases as temperature goes up. The variation is not linear, but can be tailored in manufacture to meet many specifications. Typical range is from −0.16%/deg F (−0.3%/deg C) to −2.8%/deg F (−5%/deg C). See "Thermistor Nomograph," Mid-Oct '55, p I-22, for solution of general resistance equation.

Incandescent bulbs have an opposite characteristic; resistance increases with temperature, making them effective as current (and voltage) limiters. Nominal temperature-resistance change for tungsten is 0.25%/deg F (0.45%/deg C).

Voltage

Thyrite resistors increase in current-carrying capacity by some power of the applied voltage. They are available in many ranges, and are made by pressing and sintering mixtures of silicon carbide and ceramic binders. They are common in industrial control circuits to bypass voltage surges. A typical unit decreases resistance by 10 times when voltage is doubled.

Pressure or force

Carbon piles decrease in resistance with pressure as a result of increasing area of contact between carbon particles. Repeatability is good. And some powders, such as a mixture of silicon and carbon, have resistances as low as 150 ohm/cm³, but repeatability is not as good.

Strain gages depend on resistance changes in wire when tension is applied. Changes are small, and the resistance range is from 60 to 1000 ohms.

Light

Cadmium sulphide film deposited on a glass base will show significant decrease in resistance when subjected to light, but not always repeatably. Voltage and temperature also affect resistance. A typical element (Canadian Marconi Co, Montreal) has a range of 100 to 10^8 ohms. Power rating is low—fractions of a watt.

Magnetic field

Indium antimonide can be utilized in magnetoresistive devices that increase in resistance approximately as the square of the magnetic induction. A typical 0.25-w device (Ohio Semiconductors, Inc, Columbus) increases resistance 10-fold when a 10 kilogauss field is applied; total resistance range is about 1 to 25 ohm; response can be linear or non-linear, depending on design.

non-precision, non-critical applications; and metal film for the rest. Here are some interesting variations of these two:

Conductive plastic is a refinement of the composition carbon resistor. It uses finer particles of carbon and special plastics to give desired resistance. The New England Instrument Co, Woonsocket, R. I. is making precision potentiometers with such material and can get positive as well as negative resistance-temperature coefficients by proper selection of binders.

Ceramic resistors, made with silicon carbide (The Carborundum Co, Niagara Falls), are not essentially composition carbon resistors, but can operate continuously up to 1000 F (540 C) and higher. Resistances range from 0.5 to 300 ohms/cm³; max change of resistance is about 0.08%/deg F (0.15%/deg C) and 0.08%/v.

Metallized glass fibers for wound resistors have been developed to get higher resistances than is possible with wire. By evaporating thin metal films on glass threads, effective wire diameter is decreased with two advantages: fibers can be large for easy manufacture without compromising high resistance; or fibers can be small to get exceptionally high resistance in small space. Painton and Co, Ltd, England, has wound a 10-megohm resistor on a 0.4-in. dia core 2 in. long. Performance is comparable to ordinary metal film resistors.

Tin oxide and other metal oxides can give especially reliable operation at high temperatures. Some, made by Corning Glass Works, are available in 10-w range at 25 C, de-rated to zero watts at 660 F (350 C). Resistance tolerance is from 2 to 5%.

Sputtered thin-film resistors, recently announced by Bell Telephone Laboratories, are made from tantalum and titanium on glass or ceramic bases. Deposited lines can be as narrow as 0.001 in., spaced 0.001 in. apart, giving high resistance in small area. In "sputtering," ionized gas molecules bombard a cathode, dislodging material which then redeposits on nearby surfaces.

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ACKNOWLEDGEMENT

The author is grateful for information, used in the tables and charts, supplied by: Allen-Bradley Co; Ohmite Manufacturing Co; International Resistance Co; Pyrofilm Resistor Co; Post-Glover Electric Co; and Ward Leonard Electric Co.

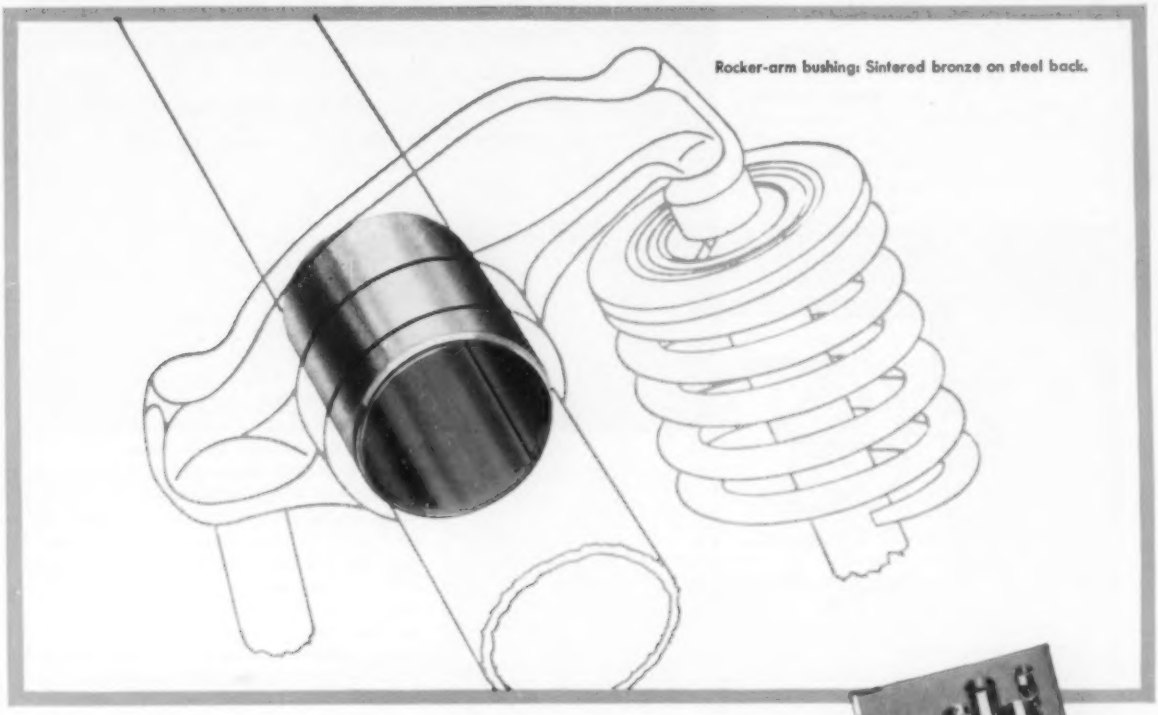
EDITOR'S NOTE: Specific details on fixed resistors appeared previously in 'Trends in Fixed Resistors," Mar '52, p 124, covering composition carbon, wirewound, deposited carbon, boron-carbon, and printed-circuit types. Color code was also explained.

"Semi-conductors—Revolution at Your Elbow," Apr 14 '58, p 60, discusses the negative temperature coefficient in resistors. "Types and Uses of Thermistors," Mid-Sept '58, p I-16, includes a performance table, typical circuits and applications.

Carrying the rocker-arm load . . .

FORMED BUSHINGS

SAVE SPACE—SAVE WEIGHT—SAVE COST!



Rocker-arm bushing: Sintered bronze on steel back.

Here's a typical application in which the design engineer uses formed bushings to meet both performance and cost demands.

This rocker-arm bushing is formed from sintered bronze-on-steel strip. In fast oscillation, at 200 p.s.i. average loading, it has an average life of 5,000 hours, or 150,000 miles. Cost-wise, you will find it attractive. Space and weight are saved, with no sacrifice of strength or service life.

There are countless other applications in motor, machine and accessory design, where formed bushings deliver equal satisfaction. Let our engineers assist you. Consultation is free—no obligation.

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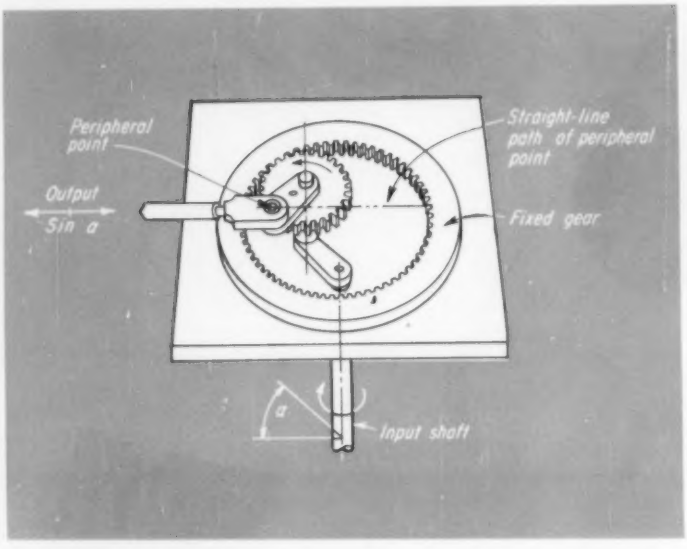
5 CARDAN-GEAR

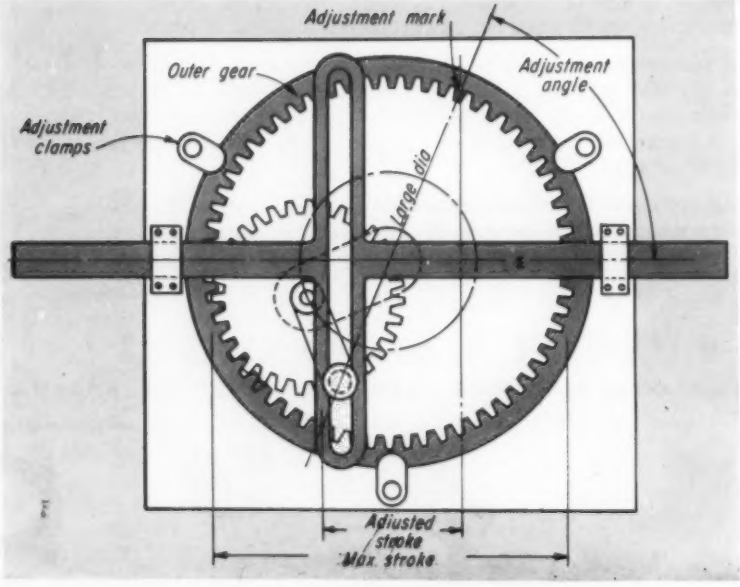
SIGMUND RAPPAPORT, *kinematician*
Ford Instrument Co, Div of Sperry Rand Co

These gearing arrangements convert rotation into straight-line motion, without need for slideways. A selection of linkages that do the same job will be illustrated by the same author in the next Design issue. Mr. Rappaport is also adjunct professor of kinematics at Brooklyn Polytechnic Institute.



1

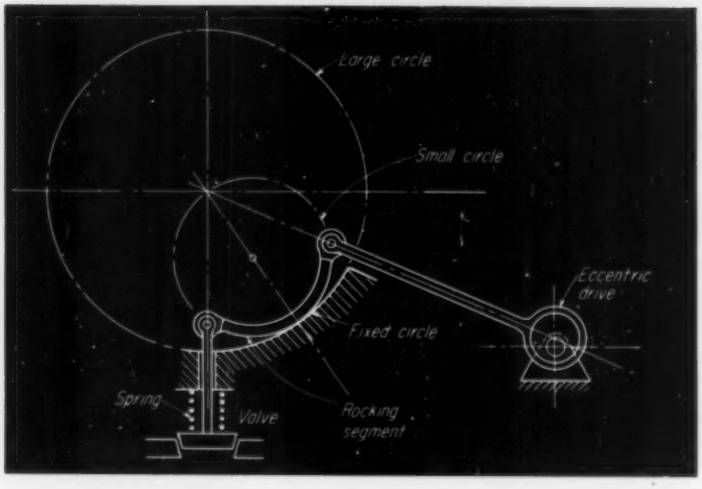
Cardan gearing . . .
works on the principle that any point on the periphery of a circle rolling on the inside of another circle describes, in general, a hypocycloid. This curve degenerates into a true straight line (diameter of the larger circle) if diameters of both circles are in the ratio of 1:2. Rotation of input shaft causes small gear to roll around the inside of the fixed gear. A pin located on pitch circle of the small gear describes a straight line. Its linear displacement is proportional to the theoretically true sine or cosine of the angle through which the input shaft is rotated. Among other applications, Cardan gearing is used in computers, as a component solver (angle resolver).



2

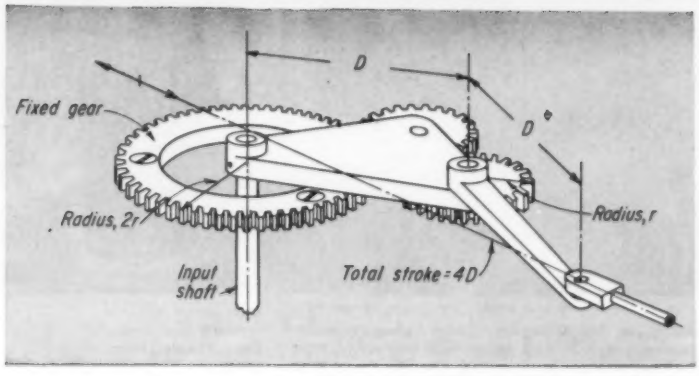
Cardan gearing and Scotch yoke . . .
in combination provide an adjustable stroke. Angular position of outer gear is adjustable. Adjusted stroke equals the projection of the large dia, along which the drive pin travels, upon the Scotch-yoke centerline. Yoke motion is simple harmonic.

MECHANISMS



3

Valve drive . . . exemplifies how Cardan principle may be applied. A segment of the smaller circle rocks to and fro on a circular segment whose radius is twice as large. Input and output rods are each attached to points on the small circle. Both these points describe straight lines. Guide of the valve rod prevents the rocking member from slipping.

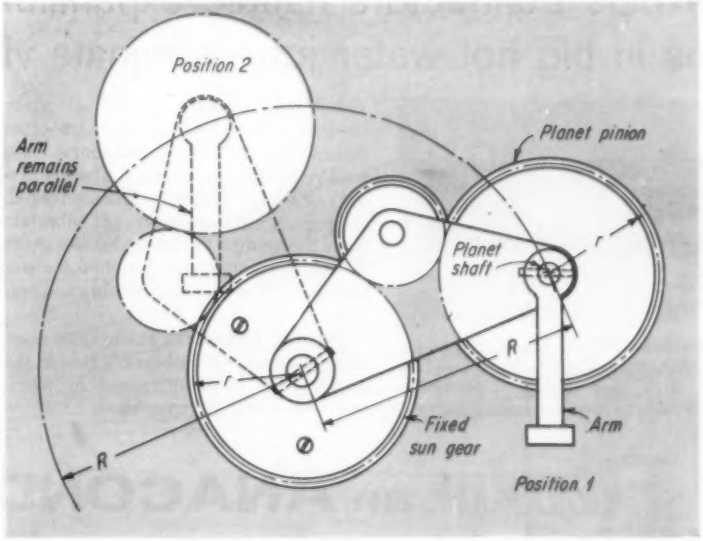


4

Simplified Cardan principle . . . does away with need for the relatively expensive internal gear. Here, only spur gears may be used and the basic requirements should be met, i.e. the 1:2 ratio and the proper direction of rotation. Latter requirement is easily achieved by introducing an idler gear, whose size is immaterial. In addition to cheapness, this drive delivers a far larger stroke for the comparative size of its gears.

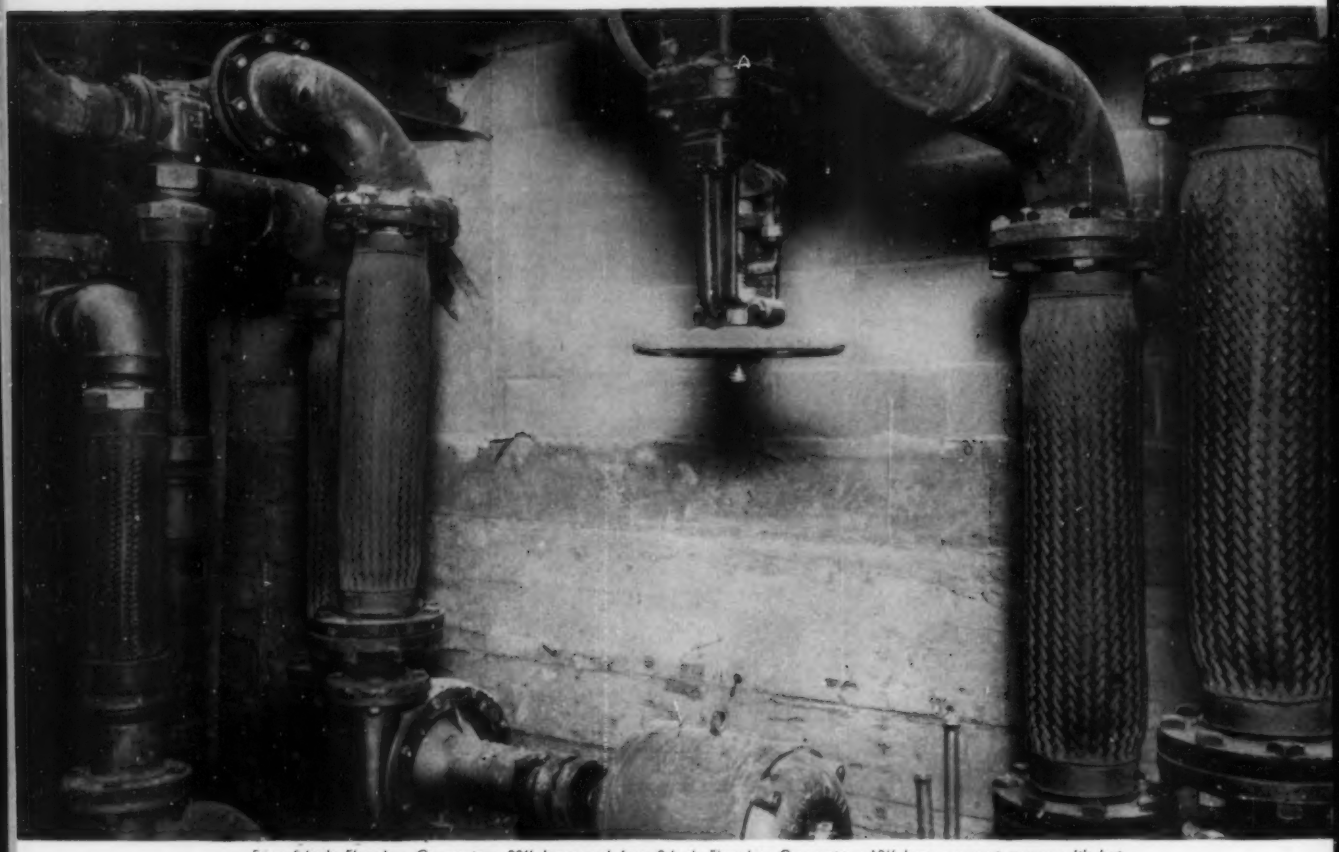
5

Rearrangement of gearing . . . in (4) results in another useful motion. If the fixed sun-gear and planet pinion are in the ratio of 1:1, then an arm fixed to the planet shaft will stay parallel to itself during rotation, while any point on it describes a circle of radius *R*. An example of application: in conjugate pairs for punching holes on moving webs of paper.



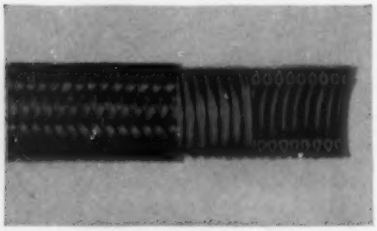
APPLICATION HINTS:

Ways to simplify construction and cut costs with Flexpipe®



Four 5-inch Flexpipe Connectors 30" long and four 3-inch Flexpipe Connectors 18" long connect pumps with hot water heating mains in big new Detroit Lakes, Minnesota, Senior High School. Architects: Traynor & Hermanson, St. Cloud, Minn. Engineers: Gausman & Moore Inc., St. Paul. Mechanical contractors: Holm Brothers, Atwater, Minn.

Flexpipe connectors handle expansion on long horizontal runs in big hot water job—eliminate vibration from pumps



FLEXPIPE'S flexible core can be either tin bronze, hot-dipped galvanized steel or stainless steel. End fittings (attached): flanges, threaded males and welding nipples.

The multi-structure design of many modern schools and institutions often makes necessary long horizontal runs for the heating mains. In hot water systems, it is very desirable, if not essential, to prevent transmission of vibration from the pumps to the mains. Flexpipe flexible connectors are designed for this service—will reduce pump vibration and noise.

Flexpipe connectors at the same time take up expansion and contraction in the mains. Thus in many cases they eliminate the need for expansion bends — make possible smaller, more economical tunnels—simplify and speed installation, reduce maintenance.

WHERE TO BUY: Flexpipe connectors come in convenient standard sizes, are sold by leading distributors. For the name and address of the one serving your area, or for more detailed information, write to: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ontario. 58227 Rev.

Flexpipe® an ANACONDA® product

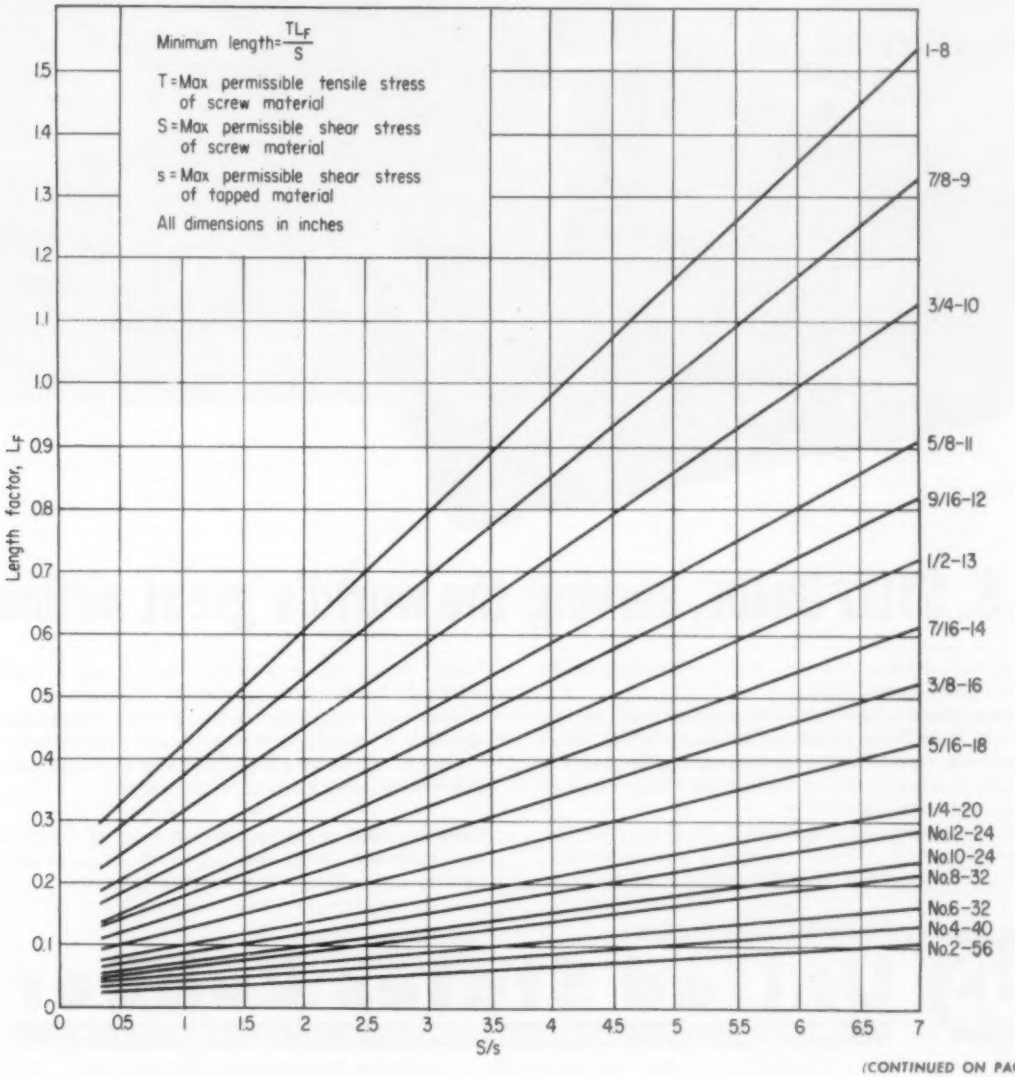
minimum screw-lengths for TAPPED HOLES

For National Standard Coarse and Fine Thread series, sizes #2 to 1 in. dia.

GIL RISKE, *senior engineer*
Hannifin Co, Div of Parker-Hannifin Corp.
Des Plaines, Ill.

A frequent design problem is: How far should a screw be engaged in a tapped hole for stripping strength to equal screw tensile strength? These two charts supply quick answers to the problem, whether the tapped part and screw are of the same or different materials. All you need know is max safe tensile and shear stresses for the materials; then the charts, plus their simple formula, will do the rest.

1 COARSE THREADS



(CONTINUED ON PAGE 71)

US SteepGrade CONVEYOR BELTS

U. S. STEEPGRADE, serving the world's great airlines

When any industry heavily favors one type of belting, it's for a reason worth investigating.

Next time you're at an airport chances are you'll be able to see U. S. SteepGrade Conveyor Belting in action. You'll see it carrying cargoes on steep inclines and declines—as steep as 45 degrees. It speeds up loading, reduces manual labor for today's leading airlines.

Notice the gripper cleats in SteepGrade. These cleats are *not* attached or cut in; they are *molded*—a true and integral part of the belt. That's why they cannot be torn off by heavy boxes. SteepGrade is weather-resistant, will not stiffen in extremely low temperatures and is self-cleaning.

And just as SteepGrade is necessary to airlines' operation, so also is it indispensable in many other industries.

SteepGrade Belts—plus engineering assistance—are available through your local "U. S." Distributor.

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WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

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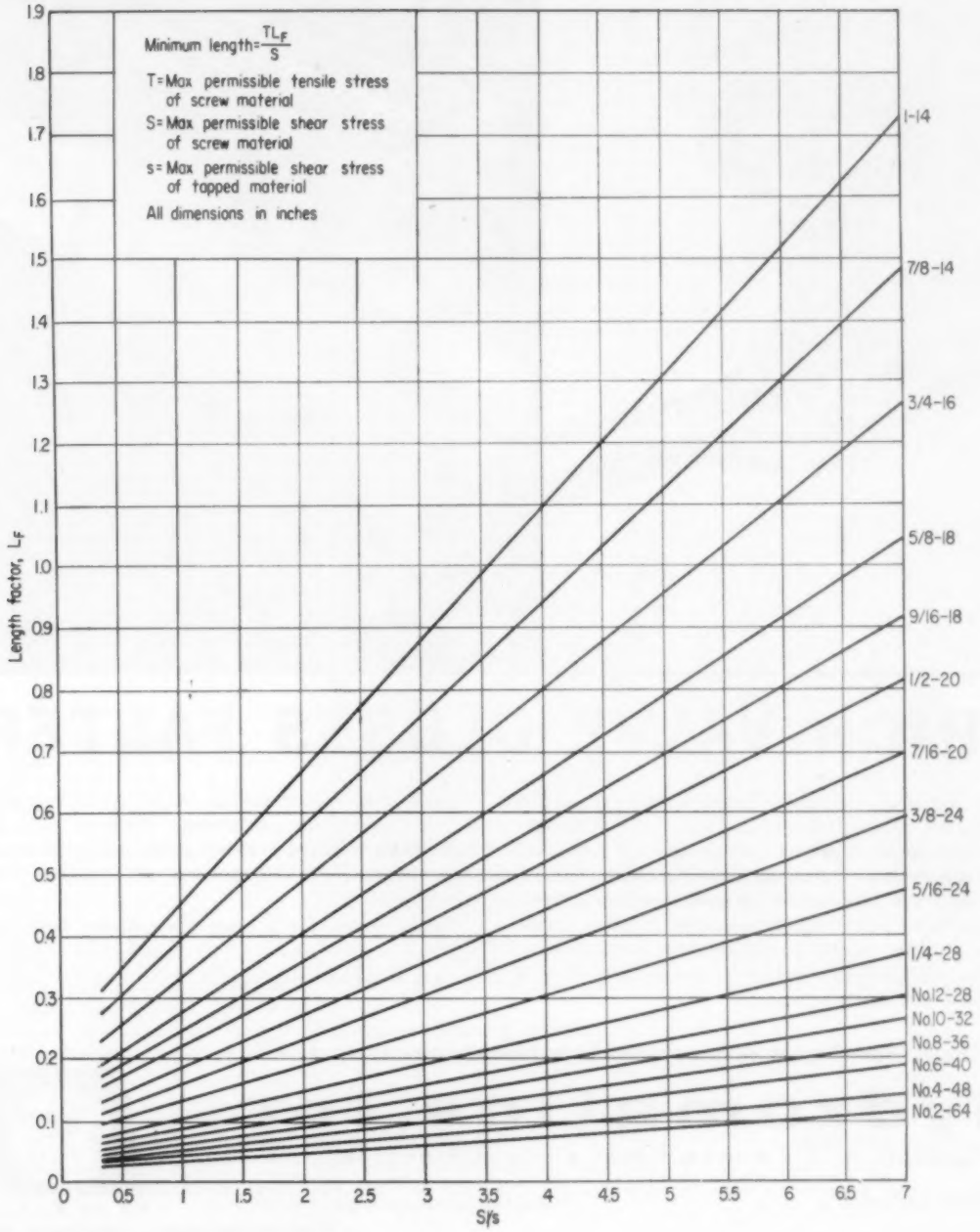
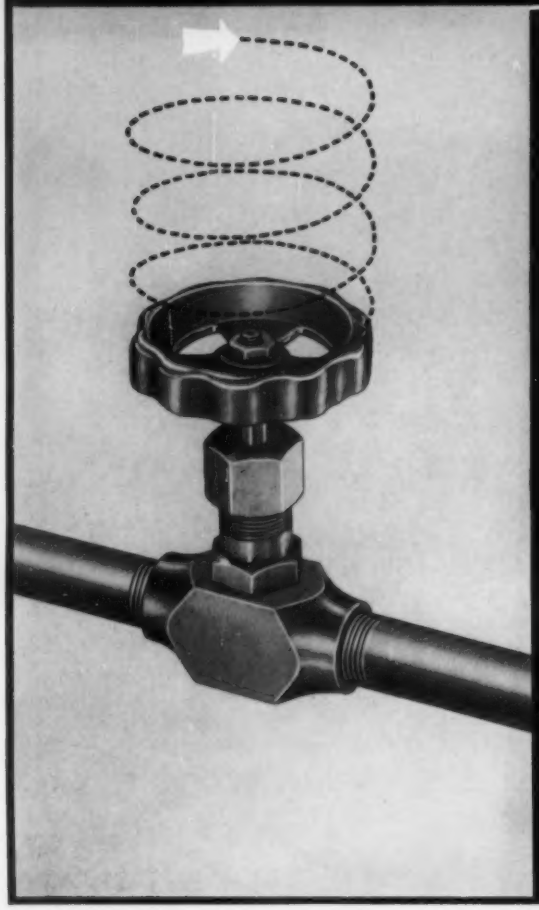
minimum screw-lengths for TAPPED HOLES *(CONTINUED)*

2 FINE THREADS



FLO-BALL 715 makes needle valves obsolete



WHICH VALVE CLOSES FASTER?

Unlike the many turns required to operate a needle valve, the Hydromatics ***FLO•BALL 715,*** shown on the right, closes instantly with a mere ¼ turn . . . **positive action** at flow pressures up to 3,000 psi with just a 4 inch-pound torque! And the arrow-shaped handle shows both open and closed positions at a glance. Exclusive ***FLO•BALL*** straight-thru design has 100% flow efficiency—more than double the flow of needle valves.

Ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, etc., the ***FLO•BALL*** features zero leakage, universal mounting, removable flanges, and all stainless steel construction.

Write today for a complete catalog describing this valve and others for corrosive and cryogenic media. Also special designs for throttling flow control.

The *FLO•BALL* costs no more than old fashioned screw-type valves!

Hydromatics, Inc.

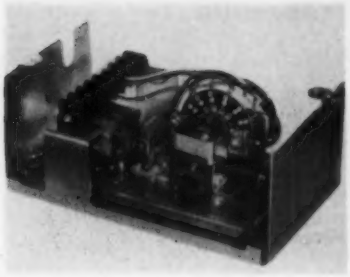
LIVINGSTON, N. J. • WYMAN 2-4900 • TWX = LIVINGSTON, N. J. 120

FLO-BALL

Copyright 1959 Hydromatics, Inc.

Exceptional engineering employment opportunities—write today!

SIGNIFICANT COMPONENTS MATERIALS PROCESSES



Sequence controller . . .

is capable of switching from 2 to 12 circuits in predetermined sequence. Electrically-operated device will repeat same sequence as long as actuating pulses are fed into it. Pulses can originate from limit or foot switch, photoelectric control relay or any conventional equipment normally employed by user. Switch contacts are primarily pilot duty, 3 amp at 115 v ac. Takes one step in switching sequence for each energizing pulse fed in, but can be supplied to take two or more steps, depending on individual requirements. Almost limitless number of sequences and sequence combinations are said to be possible. Fully packaged unit lists for $30. Enclosed units are $12 to $5 each, depending upon quantity. Standard controllers from stock; special orders, up to 4 wk delivery. **Warco Industries Inc, 6625 Delmar Blvd, St Louis 3.**

Circle 300, Reader Service Card

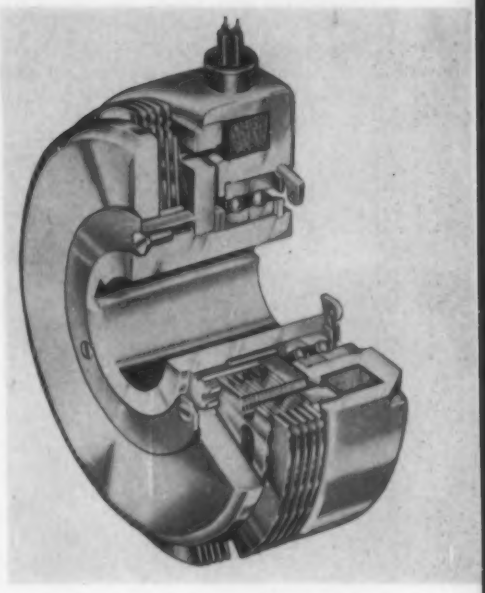
Magnetic motor starters . . .

rated through 15 hp, 440/550 v, incorporates such control features as components that are removable from the front, dual voltage coils that can be reconnected on the job and trip-free thermal overload relays with trip indicator. Encapsulated dual voltage magnet coils are rated 110/220 or 220/440 v, 50 or 60 cps. A molded terminal board in each coil accepts leads and simplifies coil and voltage selection. Coil accepts plug-in pushbutton or selector switch. Contacts are front replaceable without disturbing wiring. Pushbutton or selector switches, pilot light, auxiliary contacts or third overload relays may be added. List prices range from $34 to $59 in general purpose enclosures. From stock. **Furnas Electric Co, 1000 McKee St, Batavia, Ill.**

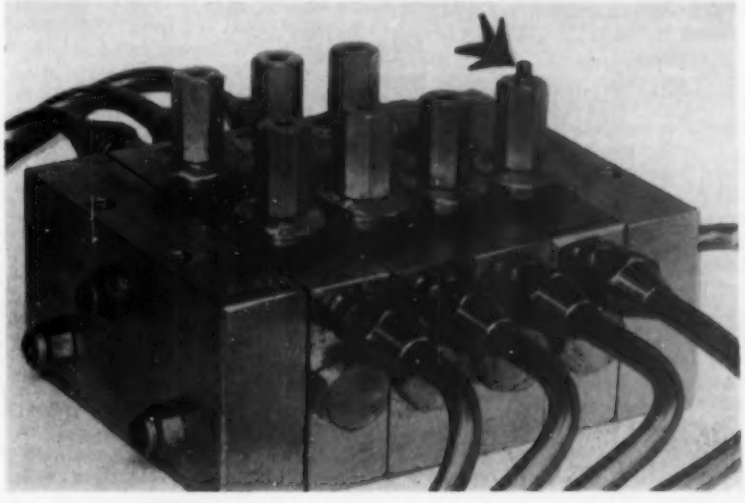
Circle 301, Reader Service Card

Electromagnetic clutch has stationary coil . . .

which eliminates slip rings and is a German-designed unit now being manufactured in this country. Designed for use in semi and fully automatic machines. Installation can be on motor shaft or countershaft, with vertical mounting often possible. Annular flux is through plates, said to increase max torque capacity (ratings range from 14.5 to 1812 lb-ft) and to assure automatic take-up. Immersed in oil, most slipping energy is absorbed in oil film on clutch plates. Driven steel plates have sine wave conformation which overcomes residual magnetism and hydrostatic film strength. 90-v coils are standard, and since 110 v ac rectifies to 90 v dc, no transformer is needed on standard unit. Axially immovable magnet body is ball-bearing mounted on clutch hub. Energizing coil causes magnetic flux to short circuit through multiple disks, pulling armature and clamping disks together. Can be used as brake as well as clutch. Available in eight sizes from 3.3 to 11.5 in. dia, with ¼ to 34½ hp capacity range. Immediate delivery of experimental quantities; production quantities will be competitively priced. **Twin Disc Clutch Co, Racine, Wis.**



Circle 302, Reader Service Card



Pop-up indicating pins . . .

locate blockage in a centralized lubrication system and, when blocked condition is cleared, automatically return to normal position. Available in spring pressures of 250 to 2,500 psi, in ⅛ and ¼ in. NPT sizes. Reset indicator is screwed into alternate outlet or test plug tap of each outgoing line from master and secondary distributors of system. Indicators are $1 each. Delivery within 1 wk. **Trabon Engineering Corp, Solon, Ohio.**

Circle 303, Reader Service Card

. . . CONTINUED ON PAGE 74

Rechargeable cells . . .

have hermetically-sealed construction said to eliminate addition of liquids required by earlier nickel-cadmium batteries. Individual cells, rated at 1.25 v, include six button-type units, ranging from $\frac{7}{16}$ in. dia to slightly larger than a silver dollar. Offered in eight sizes and a range of multiple cell batteries. Also available as single-cell batteries in penlight (AA) and standard flashlight battery (D) sizes. Connecting cells in series, stacking them in columns and using conductive silver wax as an intercell connection and for contour moldings, makes possible a wide range of multiple-cell batteries in various voltages. Operate in temperatures of 0 to 115 F. Standard unit prices start at $1. Delivery, 15 to 30 days. **Burgess Battery Co, Freeport, Ill.**

Circle 304, Reader Service Card

Speed reducers . . .

said to transmit as much as 80% more horsepower than conventional work gear units. 1 to 40 hp units, to be available in mid-October, have torque range of 1360 through 20,250 in.-lb, depending on unit size and ratio. Use of fan cooling, centrifugally cast bronze gears and special heat treating techniques on alloy steel worms are reported to permit higher input horsepower and output torque ratings with smaller units. Worms are cut integral with shaft and ground to high surface finish on both thread flanks, with large shaft extension diameter to permit increased overhung load capacity. Gears have centrifugally cast bronze rims with high tin-nickel content, made integral with cast iron center. Taper roller bearings are used on both worm and gear shafts. Worm bearings are mounted directly in housing bore. List prices range from $100 to $500. **Cleveland Worm & Gear Co, 3300 E 80th St, Cleveland 4.**

Circle 305, Reader Service Card

Inertia-damped servo motor . . .

for — 65.2 to 392 F available in size 15 unit. Consists of standard servo motor to which drag cup, integral with rear shaft extension, has been added. **Kearfott Co Inc, 1500 Main Ave, Clifton, NJ.**

Circle 306, Reader Service Card

Drawn soft metals . . .

as fine as 0.000,7 and less are said to be possible employing a new process. Chemically pure platinum, gold, aluminum and nickel; iron-free copper; aluminum-clad copper and silver furnished bare or enamel. Aluminum and aluminum-clad copper wire supplied enameled or anodized. **Secon Metals Corp, 7 Intervale St, White Plains, NY.**

Circle 307, Reader Service Card

Dual-bowl filter assemblies . . .

for system operating pressures up to 5,000 psi cover from 2 to 24 gpm flow range and 200 to 2,300 scfm with air at 3,000 psi. Six filter media available for filtration 2 to 250 microns, temperatures — 350 to 350 F. Filter head available with by-pass valve. **Bendix Filter Div, Bendix Aviation Corp, 434 W 12 Mile Rd, Madison Heights, Mich.**

Circle 308, Reader Service Card

High-temperature anchor nut..

is made in A286 stainless for 1200 F use and in M252 for 1400 F service. Retainers may be of any material compatible with structure to which they are to be fastened. **Kaynar Mfg Co Inc, Kaylock Div, Box 2001, Terminal Annex, Los Angeles 54.**

Circle 309, Reader Service Card

Potted battery power packs .

can be made up of any number of nickel-cadmium button cell batteries to fit any configuration. Cells are potted in plastic to any size, shape, color and electrical capacity. Designs employ all sizes of cells, each of which has nominal rating of 1.2 v. **Gulton Industries Inc, 212 Durham Ave, Metuchen, NJ.**

Circle 310, Reader Service Card

Miniature indicator lights . . .

is reported to be moisture proof and to supply visability for 60,000 hr at 5 v dc, 0.060 amp. Lamps and lens assembly molded to mounting stem. In various translucent colors. Mount in clearance hole for No. 10 screw. Behind-panel depth is $\frac{47}{64}$ in. Measures $\frac{47}{64}$ x $\frac{47}{64}$ in. long. **Hetherington Inc, 1420 Delmar Dr, Folcroft, Penna.**

Circle 311, Reader Service Card

Miniature thermometer . . .

for operation from — 100 to 500 F has resistance of 470 ohm at 32 F, which varies at rate of about 1 ohm per deg F. Measures 0.156 x 0.281 in. long. Platinum sensing element is potted. Calibration accuracies of $\pm \frac{1}{4}$, $\frac{1}{2}$ and 1% available from stock. Curves, points and/or equations are offered with each unit. **Minco Products Inc, 740 Washington Ave North, Minneapolis 1.**

Circle 312, Reader Service Card

Actuator motor . . .

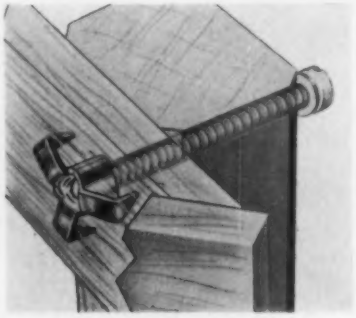
is 26 v dc compound wound reversible motor, rated $1\frac{3}{4}$ hp. Has speed of 10,500 rpm and is equipped with brake having static torque of 500 in.-oz. Designed to meet requirements of MIL-M-H609A. Measures 7 x 4 in. dia. **Electro Products Div, Western Gear Corp, 132 W Colorado Blvd, Pasadena, Calif.**

Circle 313, Reader Service Card

Running time meters . . .

register from $\frac{1}{10}$ sec to 99,999 hr in ranges of seconds or tenths of sec; min., tenths or hundredths of min.; hr, tenths or hundredths of hr. Motor can be specified for 115 or 220 v ac, 60, 50 or 25 cps operation. **Cramer Controls Corp, Centerbrook, Conn.**

Circle 314, Reader Service Card



Threaded steel insert . . .

for use with wood, plastic, sandwich panels and other assemblies held together by machine screws. Three prongs bite into the wood without splitting. Permits machine screw to be withdrawn and replaced indefinitely. Size is $\frac{1}{4}$ x $\frac{15}{16}$ in. over-all. Prongs are $\frac{1}{4}$ in. deep by $\frac{7}{8}$ in. OD. $\frac{3}{8}$ in. pin hole is required. **Diamond Expansion Bolt Co Inc, Garwood, NJ.**

Circle 315, Reader Service Card

Panel wireway . . .

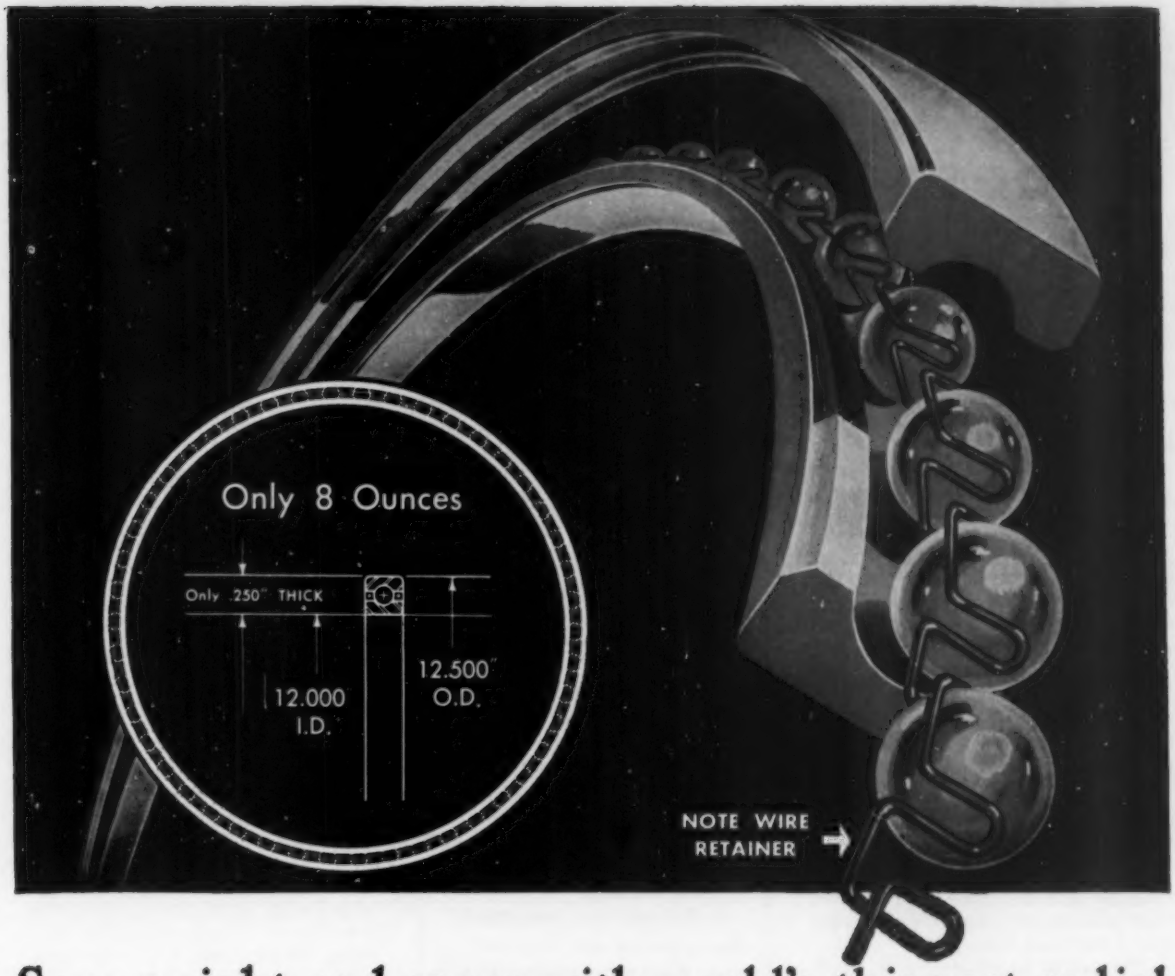
has independent top, bottom and sides to adapt to every installation. Tracks molded into base accept side pieces to make up any width or size ducts. Mounting screws permanently fasten them. **ECP Corp, 4726 Superior Ave, Cleveland 3.**

Circle 316, Reader Service Card

Automatically draining filter...

for air-operated tools and equipment admits air to pilot valve chamber whenever

. . . CONTINUED ON PAGE 76



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

. . . now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

X-561R

All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings

B.F.Goodrich

Does your product need rubber that costs 20¢ a pound, or 75¢?

Use this B.F.Goodrich check list to cut costs for molded or other special rubber parts

COSTS of rubber compounds alone vary from 20¢ a pound to 75¢. And rubber parts with tight tolerances cost considerably more than those with wider tolerances. That's why it's important to give all the details when specifying molded or other special rubber parts for your products.

The B.F.Goodrich check list on the right will help you assemble these facts. B.F.Goodrich engineers use this information to develop the rubber part to do the job for less. These men know which rubber compounds can stand the heat, chemicals, weight, strain, twisting and stretching your product will be subjected to and how to test the part before it is used.

Because of its equipment and production facilities, B.F.Goodrich can efficiently mass-produce all shapes, sizes and types of molded, lathe-cut, or other special parts. For example, hydraulic brake cups made by B.F. Goodrich are used by the millions in cars, trucks, airplanes; B.F.Goodrich seals for automatic transmissions are widely used in automobiles; and B.F.Goodrich rubber mountings absorb equipment-wrecking vibrations on rock shakers, punch presses and other vibrating machines.

Not every problem can justify the kind of research needed to develop the exact rubber part you want, but some of the big ones do. If you are designing an important product which needs a rubber part to help its performance or increase its value, assemble the facts using the B.F.Goodrich check list and send them to us. *B.F.Goodrich Industrial Products Company, Department M-709, Akron 18, Ohio.*

B.F.Goodrich Check List for specifying rubber parts

What is part's function?
- a. Does it turn or is it stationary?
- b. Does it drive something—what speed?
- c. Does it seal something—where is the seal, ID, OD, or edge?

On what kind of equipment is it used?
- a. For office use?
- b. For industrial use?

Does it operate in or around oil?
- a. What kind?
- b. Is there high temperature?

Are there any acids involved?
- a. What is the concentration?

Is there high temperature?
- a. Intermittent or constant?
- b. Dry or liquid?

Is there abrasion?
- a. Wet or dry?

What physicals are needed?
- a. Durometer
- b. Tensile
- c. Elongation
- d. Compression Set
- e. Is there an ASTM spec involved?

Dimensional tolerances required?

Must the part be non-marking?

Is there pressure?

Must OD be concentric?

Quantity needed?
- a. Immediate
- b. Future requirements

B.F.Goodrich *industrial rubber products*

liquid accumulates, opening scavenger valve. Trapped liquid and impurities are then blown out. Available ¼ through 1 in. Plastic bowls for up to 150 psi; metal bowls for up to 250 psi. **Watts Regulator Co, Industrial Div, Lawrence, Mass.**

Circle 317, Reader Service Card

High-temperature servo motor

in size 10 operates at temperatures from —65.2 to 392 F. Stall torque, 0.035 in.-oz: no load speed, 3,800 rpm. Stator integrally cast in thermosetting resin. Weighs 1.43 oz. **Kearfott Co Inc, 1500 Main Ave, Clifton, NJ.**

Circle 318, Reader Service Card

Totally-enclosed cycle timer . . .

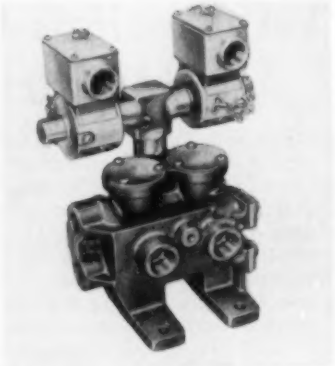
is motor-driven. Repeats set cycle or sequence as long as motor circuit is energized. Switch rated 25 amp or ½ hp at 250 v ac. Available for 120 or 240 v operation, 50 or 60 cps, with intervals of 15 and 30 sec, 1, 2, 3, 4, 5, 6, 10, 15, 30, 45, 60, 120 and 180 min. and 8, 12 and 24 hr. **Haydon Div, General Time Corp, 245 E Elm St, Torrington, Conn.**

Circle 319, Reader Service Card

Shorter, lighter brakes . . .

than comparable models presently available are offered in torque ratings of 125, 175 and 230 ft-lb; torque ratings up to and including 575 ft-lb are expected to be available by December. Brakes have flange for mounting on NEMA C flanges of motor frames 324UC through 405UC. **Stearns Electric Corp, 120 N Broadway St, Milwaukee 2.**

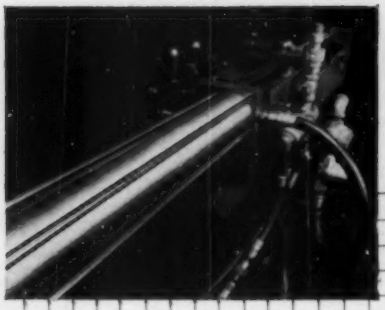
Circle 320, Reader Service Card



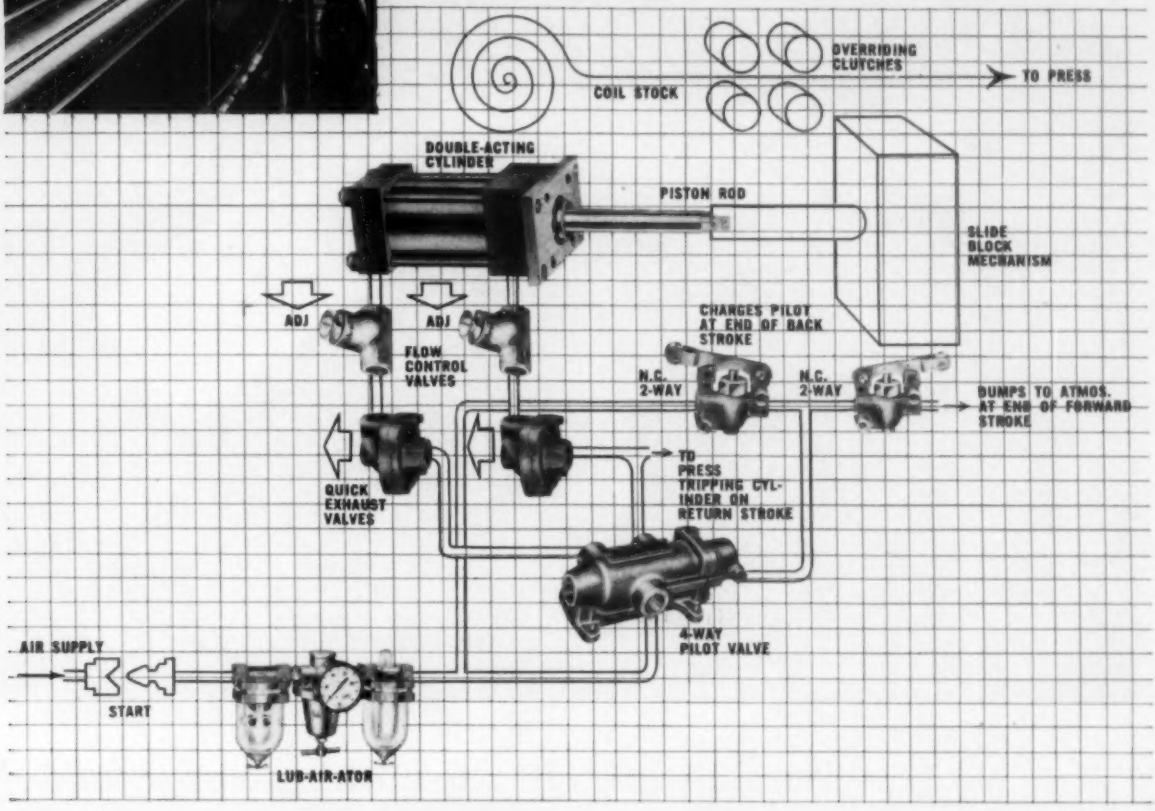
Momentary contact air valves . . .

are solenoid-actuated. In single solenoid, two-position four-way valve, solenoid is actuated by electric impulse and plunger actuates pilot valve, which in turn operates main valve. Dual units utilize one

(Continued on page 80)



This is an example of how OEM use Schrader. The hookup of Schrader Air Products in the large schematic is used by the Cooper-Weymouth Company of Stratford, Connecticut, to operate its patented power press slide-feed. Power to the mechanism is supplied by a Schrader double-acting cylinder, the front head of which is machined as an integral part of the overriding clutch. At the end of the forward stroke, the slide block operates a normally-closed 2-way valve, which dumps the pilot of a 4-way control valve. This reverses cylinder piston, and the slide block mounted on it, to return for the next stroke. Another normally-closed 2-way valve ahead of the pilot charges the 4-way pilot in a conventional reciprocating motion arrangement to start the next cycle.



ORIGINAL EQUIPMENT MANUFACTURER BUILDS STANDARD SCHRADER AIR PRODUCTS INTO AUTOMATIC TOOLS FOR SPEED, PRECISION

If your company *manufactures* machines or equipment that must push, pull, hold, position or move work repetitively . . . consider the advantages of actuating them with air. Schrader makes complete lines of Air Products that can do such jobs with dependable precision. In limitless combinations, they adapt to many special needs.

Air offers manufacturers much more than versatility. It's fast and accurate, can time to fractions of seconds at high speeds. Its economy alone is a powerful sales point. Safe, tireless, air power is simple that problems of weight, assembly, production and maintenance are enormously reduced.

These are benefits all customers look for. Add them to your products by actuating with Schrader . . . finest, most complete lines of Air Cylinders, Valves and Accessories.

Select from the full Schrader lines to plan your automation of machines. Your Schrader distributor can help you pinpoint what you need. For more data write:

Schrader®
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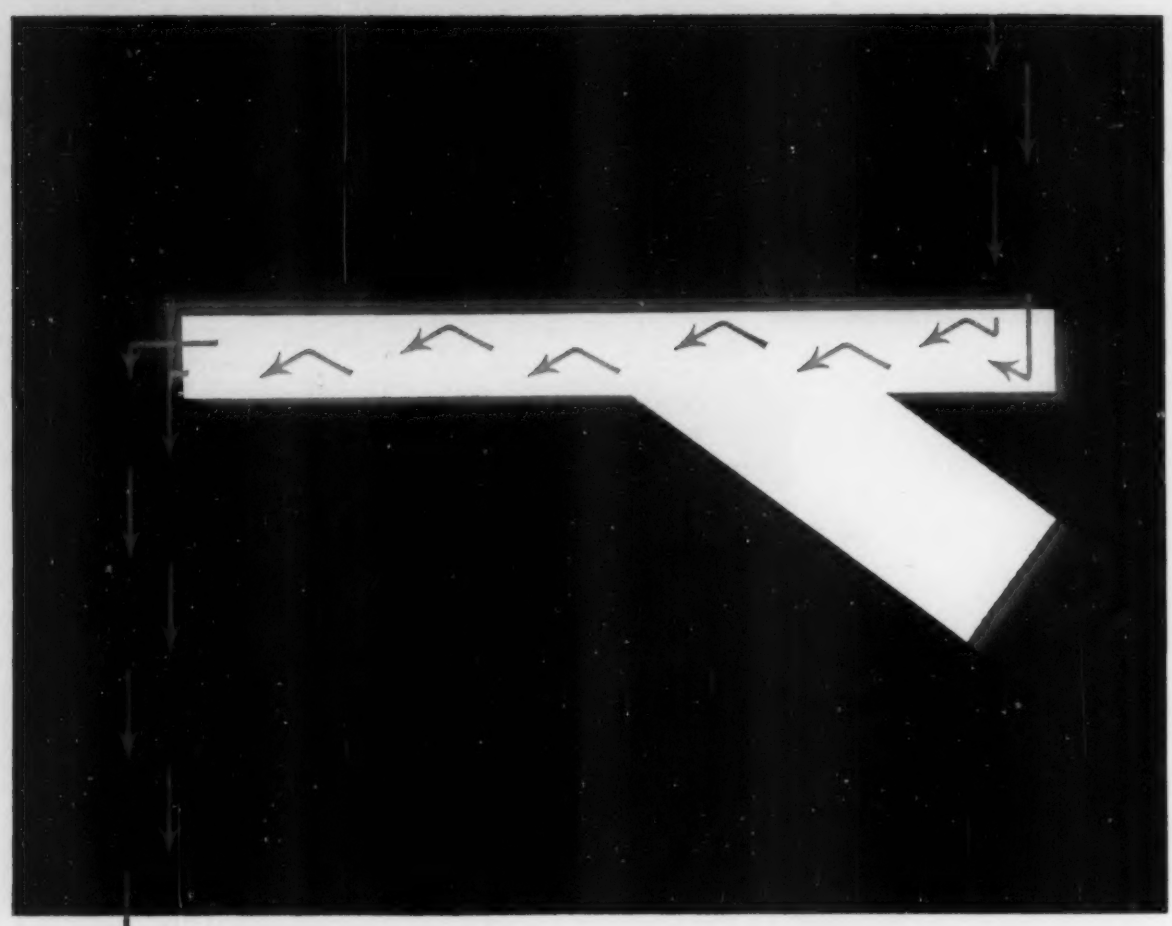
Division of Scovill Manufacturing Company, Incorporated
477 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

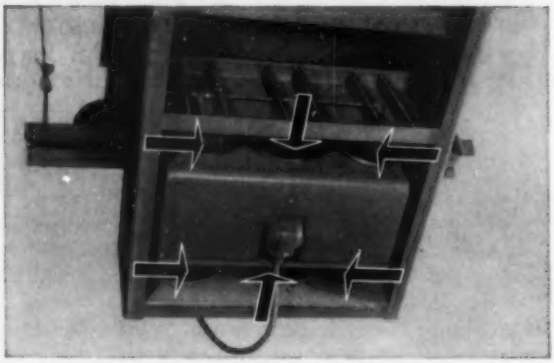


How Airmounts vibrate a unique new feeder

Firestone Airmounts amplify, modulate, and isolate vibration in Carrier Conveyor's new Amplitrol Feeder

One horsepower to do the work of ten? This is unusual. But unusual things happen with Firestone Airmounts. Here six of them used in Carrier's exclusive Amplitrol Feeder drive are so efficient they develop 90% of the driving force needed for Natural Frequency operation. They amplify the centrifugal force of small rotating motor weights into very large, uniformly distributed impulses which oscillate the trough. They also provide controlled, variable capacity feeding by simply varying the air pressure. And they run almost maintenance free.

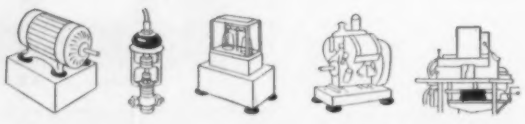
Firestone Airmounts—the same type air springs so widely used in trucks, trains, buses and automobiles—are now generating profitable new actuation and suspension ideas in many industries and in many different ways. They can serve *you*, too. *Whatever* your actuation, suspension, shock or vibration problem, why not write us for a low-cost, long-term solution with Firestone Airmounts?



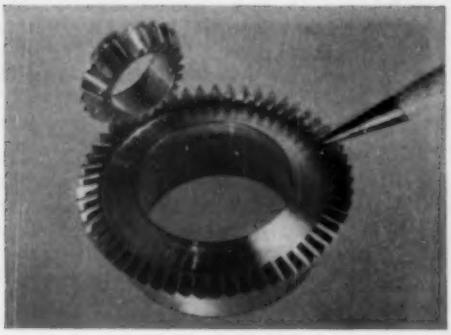
Located directly beneath the trough on opposite sides of the Amplitrol motor box are six Firestone Airmounts. Their easily controlled air pressure determines the spring stiffness which governs the stroke and capacity.

FIRESTONE **airmount**

Firestone Industrial Products Co., Noblesville, Indiana



CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.



BEVEL GEARS

When a gear or a coupling determines the *accuracy of trajectory*...

When a missile or rocket works on paper the best way to get it into the air is to see to it that all the parts agree with the paper work.

And when one of those parts is a bevel gear or coupling, Gleason engineers can help you three ways:

1. Engineering service. Our full staff of engineers is ready at all times to help you develop bevel gear combinations and Curvic® Coupling designs. They can help you make sure that either part meets your specifications.

2. Machines to cut or grind to your tolerances. You can produce any fine pitch gear—spiral bevel, hypoid, Zerol® or Coniflex®—precisely and economically with any of five Gleason machines.

No matter how rigid your specifications or the size of your parts, our engineers can help you select the right machine or combination of machines for 100% accuracy.

3. Complete testing equipment. We have engineered a series of testers for making certain that all parts do meet your critical specifications. For example, on the Gleason No. 104 Hypoid Tester you obtain a permanent test record to help you match pairs properly and to keep a graphic record of the rolling qualities, tooth spacing, and concentricity of your parts.

Any or all of these services are yours for the asking at any time.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

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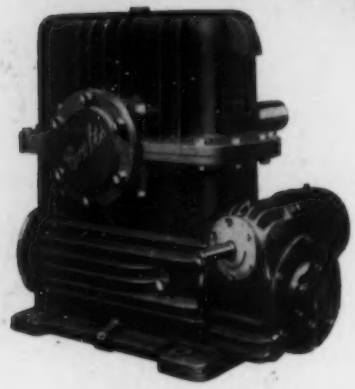
CIRCLE NO. 79 READER SERVICE CARD

FOR COMPACTNESS WITH MAXIMUM SPEED REDUCTION

CROFTS COMBINED DOUBLE WORM REDUCERS



Output torques from 2700 to 1,605,000 inch/lb. with gear ratios up to 10,000 to 1.

Three types, standard (illustrated), inverted (wormshaft above wormwheel), and vertical (vertical wormwheel shaft).

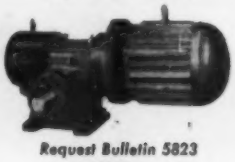
Request Bulletin 5241/AA

SOME OTHER CROFTS PRODUCTS

"Radiation" Worm Reducers, 3½ to 28-inch centers, up to 450 h.p., ratios up to 100 to 1.

Request Bulletin 751

"Radiation" Worm Gear Motors, 3½ to 14-inch centers, up to 50 h.p., in six types.



Request Bulletin 5823

Industrial Single or Double Disc Friction Clutches, ½ to 320 h.p. at 100 r.p.m.

Request Bulletin 5918

Machine Tool Multi-Disc Friction Clutches, up to 15 h.p. at 100 r.p.m.

Request Bulletin 5918

Let us know your requirements and we will make recommendations. For general information request bulletins listed above.

CROFTS U.S.A. Inc.

2544 WEST PETERSON AVENUE CHICAGO 45, ILLINOIS

EASTERN STATES DISTRIBUTOR

Rockwood Pulley Mfg. Co., Inc., 20 Crosby Street, New York 13, New York

CROFTS CANADA LTD.

2185 Madison Avenue, Montreal 28, P.Q. 25 Jutland Road, Toronto, Ont.

solenoid for latching, one for release. **Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58.**

Circle 321, Reader Service Card

Miniature pressure pickup . . .

is available in 11 standard pressure ranges from 0 to 200 to 0 to 5000 for measurement of pneumatic and hydraulic media. Resistance elements are available from 1,000 to 10,000 ohm and power rating of unit is 1 w. 1¾ x ⅞ in. high. **Bourns Inc, PO Box 2112, Riverside, Calif.**

Circle 322, Reader Service Card

Variable transformers . . .

in 2 kva series completes range between 1 and 3 kva units. Available in open, enclosed, fused, cord-plug and enclosed terminal models; single, two and three gang types; manually-operated and in 5, 15, 30 and 60 sec motor-driven assemblies. **Superior Electric Co, Dept 126, Bristol, Conn.**

Circle 323, Reader Service Card

20, 25 hp variable speed . . .

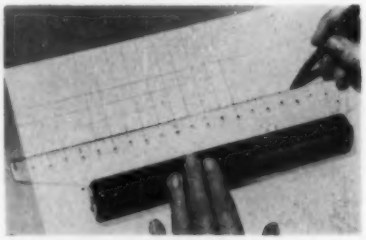
drives offer 3:1 speed range. Class II ratings and service factors to 1.4 apply. Components include long-life variable belt, adjustable mounting base for 324U and 364 frame motors, plus controlling devices and companion sheaves. **Lewellen Mfg Co, 1418 10th St, Columbus, Ind.**

Circle 324, Reader Service Card

Motor-starting relay . . .

for single-phase ac appliances handles loads up to 30 amp, 115 v. Current-type all-welded relay is for applications on stationary equipment having starting loads over 10 amp. Current required to close switch ranges from 3.5 to 30 amp. Current required to open is min of 15% less. **Metals & Controls Div, Texas Instruments Inc, 34 Forest St, Attleboro, Mass.**

Circle 325, Reader Service Card



Rolling 12-in. ruler . . .

draws parallel horizontal and vertical lines in measured distances without lifting ruler from paper. Built-in rollers allow easy movement. Spiral index window automatically measures distances between hori-

(Contiuued on page 82)

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

CONCERNING PRECISION AND PHOTOSENSITIVE GLASS

Pure precision, in any form you like . . . how? With photosensitive glass!

What could be more precise than present-day photography? What more precise than "chemical etching" which works discretely on the molecular level and does away with the variables that invariably follow such operations as grinding, drilling, cutting and engraving?

What, indeed, when we can put exactly 250,000 holes on a plate only an inch square! Each of the holes can be *precisely* the same as its 249,999 companions; they can be square or even triangular. A change in size, shape or number of holes requires only a change in negative.

Such precision is not a drawing board dream. People are *using* photosensitive glass right now: for fine-mesh 500-line screen, for brush holders for digital computers, for various substrates, for printed circuits, for micro-module wafers, for attenuator plates, for dielectric spacers and for evaporation marks.

For more details, send the coupon for a copy of our bulletin on FOTOFORM® glasses.

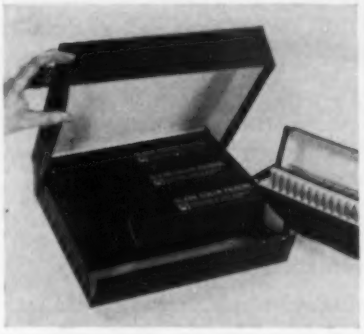
GOOD HOUSEKEEPING

If you have 2″ x 2″ light filters, are not quite happy with your facilities to store them, and would like to correct the situation, read on.

For only ten dollars we offer this compact kit of four sturdy boxes which were just *made* for holding filters. There's room for eighty filters to rest safely in slotted softwood. The boxes are covered in good-looking, long-wearing buckram.

If you'd like some fresh filters to put in the files, we have a complete set, or any part thereof, available. For three hundred and sixty dollars we'll send you the complete set of sixty-seven, including:

6 ultraviolet-transmitting, clear filters
6 ultraviolet-transmitting, visible absorbing
7 blue
7 blue-green
6 green
18 sharp cut
5 yellow
8 infrared
4 miscellaneous



We are not averse to splitting these sets if you have specialized wants. We can also provide 3⅛″ x 6½″ squares of those same filters, but without the box.

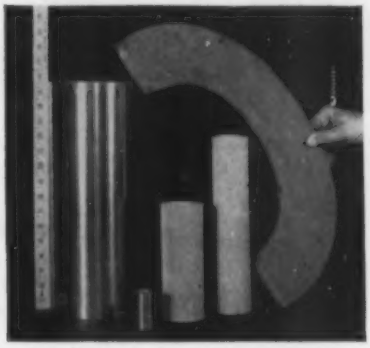
For more information on both box and filters, check the coupon.

TOO PURE TO TOUCH? "AIRLIFT" YOUR PRODUCT.

Molten metal slips down a chute without ever actually touching the chute.

Film and foil flash by over rollers without even touching them.

Tricks like these are accomplished with chutes and rollers made from a relatively new kind of nickel*—with pores in it. Air or some other gas is forced through these pores, and a cushion of gas forms to gentle products along, without a touch of contamination or scratches.



We make the porous nickel in tubes, cylinders, hemicylinders, and flat sheets up to 24″ long. We add holes or projections without secondary finishing. We do any machining needed.

Pores run with a high degree of uniformity in diameters from 1 to 45 microns, depending on space. Yield strength is a full 20,000 psi. Maximum working temperature is 300° C.

We welcome your questions, your specs, your orders.

***Of course, we realize that nickel is far removed from glass, but we figure that the people who read "This Is Glass" are the very people who will be interested in porous nickel.**

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 51-9 Crystal St., Corning, N.Y.

Please rush along: ☐ Information on color filters ☐ Bulletin on FOTOFORM Glass ☐ Data on porous nickel and also_____

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

CIRCLE NO. 81 READER SERVICE CARD 81

ACME Conveyor Attachments SAVE TIME and MONEY

UNLIMITED COMBINATIONS POSSIBLE

Acme Conveyor Chains and Attachments meet the present day need for greater speed and durability on your automatic machines — they offer smoother running operation that costs less to buy and less to maintain.

Acme Chains always keep their original accuracy and uniformity of pitch because of their high tensile strength and wear resisting properties of the hardened pins and bushings.

Prove these facts for yourself by investigating the many advantages Acme Conveyor Chains and Attachments offer you. Consult your local Industrial Distributor today, he has the full cooperation of our technical engineering department to help solve your problem.

Write Dept. 1-G for new 100-page illustrated Catalog, including new engineering section showing 36 methods of chain adjustments.

Call ACME for Service

Acme Chain Corporation
HOLYOKE MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

zontal lines as close as $\frac{1}{16}$ in. Available in inches or centimeters. German-made plastic ruler is $3.95 postpaid. **Rol-Ruler Co, Box 164, Riegelsville, Penna.**

Circle 326, Reader Service Card

Remoistenable adhesive . . .

for acetate and other plastics is clear, water-white material. Dries transparent and tack-free. When moistened with water, tack develops immediately, making possible adherence to glass, metal, wood, paper and other materials. **Adhesive Products Corp, 1660 Boone Ave, New York.**

Circle 327, Reader Service Card

Oscilloscope has plug-in . . .

units available for all signal generating and processing circuitry. Several systems are available for use with basic oscilloscope, so that sensitivity, bandwidth and other characteristics may be obtained, yet instrument remains flexible. **Electronic Tube Corp, 1200 E Mermaid Lane, Philadelphia, 18.**

Circle 328, Reader Service Card

Instrument servomechanism

kit from whose standard parts a wide variety of $1\frac{3}{8}$ in. dia electromechanical instruments can be assembled contains over 274 pieces. Provides necessary parts to construct servomechanisms, indicators and analog computing elements. Price, $472. **Servo Development Corp, 567 Main St, Westbury, NY.**

Circle 329, Reader Service Card

Retractable captive screw . . .

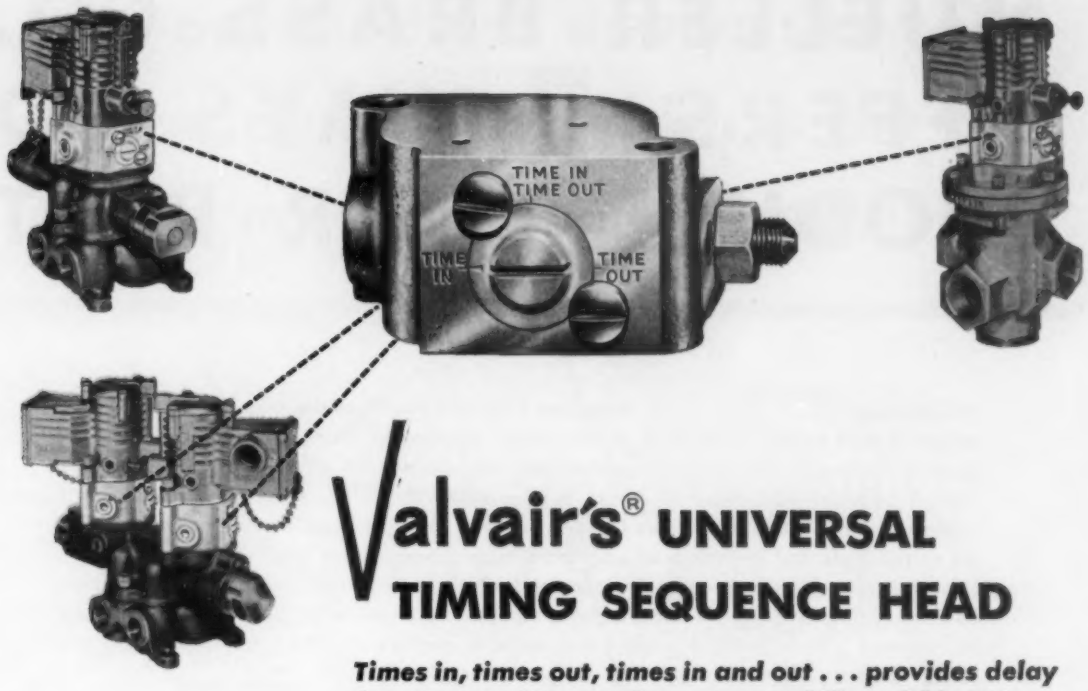
mates with any standard internally threaded member. No special tools are required for installation. Fastener has $\frac{1}{8}$-in. adjustment for gripping different panel thicknesses. Anodized aluminum nut retainer is available for panel thicknesses from 0.062 to 0.187, 0.187 to 0.312 and 0.312 to 0.437 in. **Calinoy, Div of Illinois Tool Works, 12917 Cerise Ave, Hawthorne, Calif.**

Circle 330, Reader Service Card

High-speed Diazo blue . . .

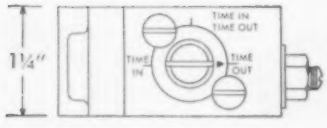
prints can be reproduced directly from translucent originals. Developed dry with aqua-ammonia vapor. Can be used with both low powered light source and high-

(Continued on page 87)



Valvair's® UNIVERSAL TIMING SEQUENCE HEAD

Times in, times out, times in and out . . . provides delay from 0 up to 30 seconds . . . repeatability within 2% . . . changes function without disassembly . . . for use with any Valvair Speed King or Inline Valve



For accurate control, to simplify circuits, to eliminate timers and relays, to lower control component installation and maintenance costs, use Valvair's universal timing sequence head. This unit is supplied in two types; one for direct mounting between the pilot and valve body; one for direct mounting on the valve body, with remote pilot control.

Function can be changed in seconds, *without disassembly* and with line pressure on the valve. Just loosen the lock screws slightly, turn the indicating barrel to the desired function mark, then tighten the lock screws.

A port is provided for installation of accessory reservoir capacity . . . delay can be extended up to several minutes. And, the Valvair name on this unit is your assurance of sound design, quality construction, micro-accurate performance and multi-million cycle dependability!

Find out how Valvair's sequence head can provide the results you want, at a cost saving you'll like, on the new equipment you're designing or on existing machines you're up-grading. Yes, this sequence head can be used on your present SPEED KING and INLINE valves, too. Ask your Valvair or Bellows Field Engineer for recommendations . . . they're located in over 125 major industrial cities.

For more information, write for Bulletin E-1A. Address Dept. PE959, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio.

Valvair AKRON 11, OHIO

Other INDUSTRIAL DIVISIONS of IBEC: The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio.

8079

MUELLER BRASS CO. OFFERS 7 WAYS TO PRODUCE YOUR PART

Mueller Brass Co., because of its diversified manufacturing facilities that encompass a wide range of fabricating methods, is in the unique position of being able to offer you, the purchaser, an intelligent, unbiased analysis and recommendation of the best, most economical method by which your particular part can be produced. As the result of over 40 years' experience, the "Methods Analysis Department" has at its command complete knowledge of the advantages and limitations of each production process. After receiving detailed knowledge concerning the end use of the part, material specified, conditions under which it must operate and other pertinent factors, these analysis engineers make their recommendations. Every detail is considered. In many cases, methods analysis engineers recommend a simple design change that makes practical a much more economical method of production. This technical service, offered only by Mueller Brass Co., is given to each individual inquiry and is your assurance that you will get the best product at the best price . . . made the one best way . . . by Mueller Brass Co.

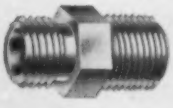
Send today for free technical literature on any one or all of the seven fabricating methods.

FORGINGS

Production equipment is available to produce press, hammer or cored forgings of any practical shape in sizes ranging from a few ounces to 150 lbs. in brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.

COLD-PREST® IMPACT EXTRUSIONS

Mueller Brass Co. has complete machinery for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Extrusions up to 28" in length are possible, depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with uniform or tapered wall sections.



SCREW MACHINE PRODUCTS

Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and non-ferrous custom parts. We can produce an infinite variety of shapes and sizes from ⅛" to 3⅛" in wide range of free cutting and specialized alloys. Complete facilities for all secondary and finishing operations, as well.

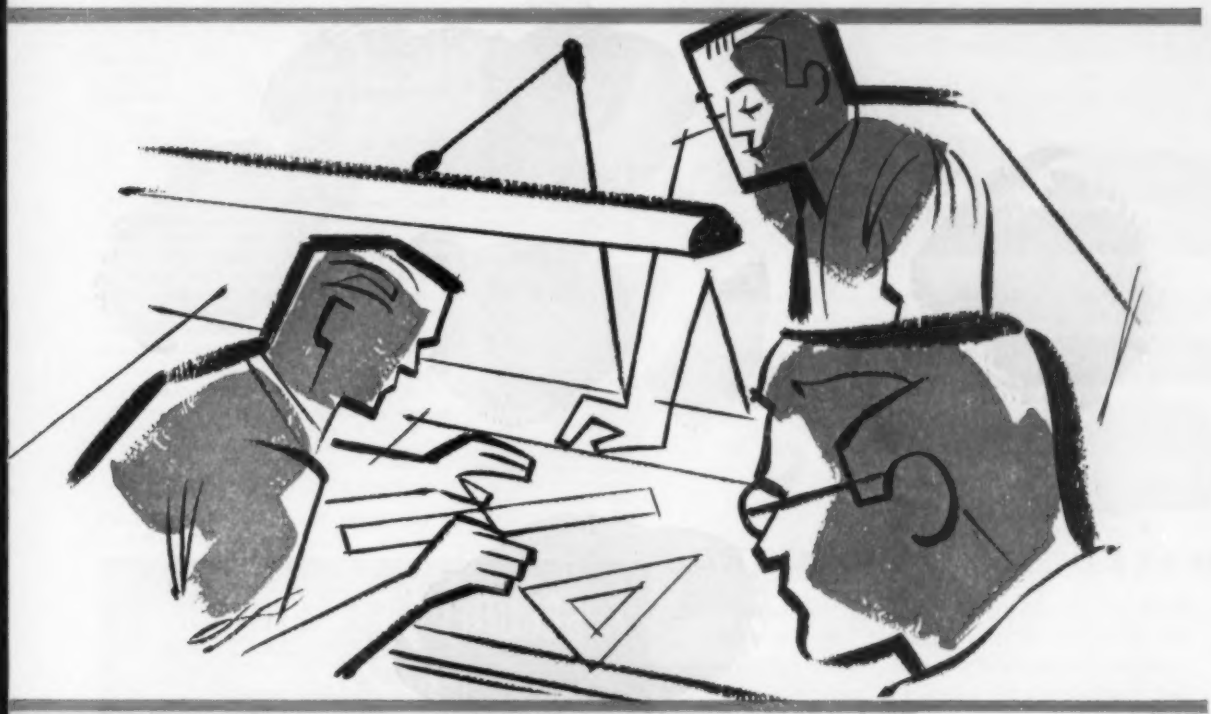
POWDER METAL PARTS

Mueller Brass Co. can supply precision Sinteel® powder metal parts in wide range of sizes and metals at high production rate. Parts available from iron, brass and copper alloys. Parts may be ordered with such characteristics as self-lubrication, controlled porosity and good electrical and magnetic properties.

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

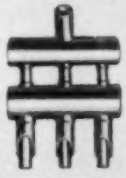
MUELLER BRASS CO.

...and our methods analysis service helps you determine which is the best ...and most economical method



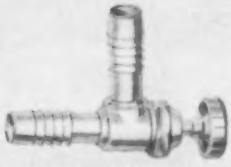
SAND CASTINGS

We specialize in the production of pressure-tight red brass castings. We utilize both metal match plate and wood patterns. Facilities include tool room and pattern shop, electric melting furnaces, high capacity core room and both bench and floor molding equipment to handle wide range of sizes.



FORMED COPPER TUBE

Mueller Brass Co. has modern facilities for forming seamless copper tube into a multitude of shapes. Forming methods used include bending, spinning, expanding or swedging, upsetting, flaring, flattening, beading and grooving, drilling and piercing, machining and joining. Formed copper tube coils are also available as single, double, spiral and serpentine shapes.



PLASTIC INJECTION MOLDING

Injection molding of plastic parts is still another process offered by the Mueller Brass Co. Parts are molded from such plastics as—nylon, polyethylenes, polyvinyl chloride, styrenes, linear acetal, chlorinated polyether, polycarbonates or polypropylene, dependent on part application.

MAN FROM MUELLER BRASS CO.

Since only Mueller Brass Co. can produce your part by all these methods, only the Man From Mueller Brass Co. can give sound advice on the one best method of production. Over 40 years of research, engineering, manufacturing and marketing experience stands behind him. When you are specifying and purchasing fabricated metal parts, call in the MAN FROM MUELLER BRASS CO.

271

PORT HURON 22, MICHIGAN

PRECISION BALLS

MATERIALS UNLIMITED

Hartford's leadership in research for better ball materials and higher precision is paying off every day for design engineers. It is paying off in a wider scope of materials, finer finishes and closer tolerances. It can pay off for you. Next time you have a problem that requires precision balls, regardless of the material characteristics required, let Hartford engineers assist you.

Do you have a copy of Hartford's Technical Guide to quick selection of precision balls for practically any requirement? Your copy will be sent promptly on request.

Specify Hartford PRECISION BALLS • BEARINGS

HARTFORD STEEL BALL CO., INC.

41 Jefferson Avenue, West Hartford, Conn.

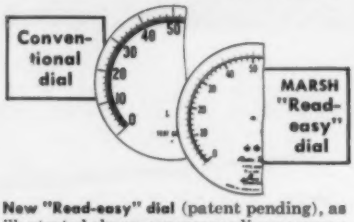
86 CIRCLE NO. 86 READER SERVICE CARD

New MARSH "Master-Test" SERIES

Twin-tip pointer enables observer to read "dead-on" by lining up twin tips like gun sight.

Unprecedented accuracy and dependability in test gauges developed to meet today's exacting requirements. Each gauge individually *dead-weight tested!* Guaranteed accurate within ¼ of 1% plus or minus of maximum dial reading over entire range.

Mirror dial also insures accurate "dead-on" reading.



"Non-parallax" dial has Plexiglas insert that assures accurate reading even when read at angle.

New "Read-easy" dial (patent pending), as illustrated above, assures reading accuracy in keeping with indicating accuracy. Also note three advanced means of reading available in all "Master-test" gauges: twin-tip pointer, mirror dial, and "non-parallax" dial as shown opposite.

Sizes 4½", 6", 8". All standard pressure ranges 0-15 psi to 0-30,000 psi, vacuum and compound.

Ask for new 20 page bulletin covering all details

MARSH INSTRUMENT CO., Dept. 39, Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd.
8407 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

CIRCLE NO. 204 READER SERVICE CARD

SECURITY PLASTICS, inc.

TAKES PLEASURE IN *Announcing*

A PLASTIC MOLDING METHOD — CAN SAVE YOU FROM 10% TO 20%

QUALITY NYLON MOLDED PARTS ARE NOW AVAILABLE WITHOUT THE USUAL HIGH MOLD COSTS. AT SECURITY, MEN WHO KNOW YOUR PROBLEMS HAVE COME UP WITH THE SOLUTION THAT MAKES POSSIBLE 7 TO 10 DAY DELIVERY OF MOST PRODUCTION SAMPLES OF NYLON MOLDED PARTS, ECONOMICALLY PRICED.

LET US PROVE OUR CLAIMS. SEND US YOUR PARTS DRAWINGS FOR QUOTATION.

HELPING TO MOLD THE FUTURE ...

SECURITY PLASTICS, inc.

4295 E. 11th Ave. Hialeah, Fla.

CIRCLE NO. 205 READER SERVICE CARD

speed machines. Samples available. Eugene Dietzgen Co, 2425 N Sheffield Ave, Chicago 14.

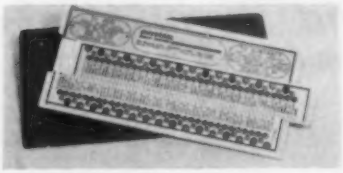
Circle 331, Reader Service Card

Medium-volume whiteprinter has 42-in. printing width, 3000-w lamp and mechanical speed ranging up to 40 fpm. Built-in air-jet separator automatically separates tracings from prints after exposure and foot treadle releases incorrectly fed stock. Fabricated from heavy-gage metal, welded and reinforced. Air filter system is said to result in cleaner lamp cylinder, cleaner prints and high rate of production. Developer for odor-free machine is stored in flat plastic 1-gal. container. Front or rear print delivery is possible and front tray can be adjusted from 18 to 24 in. deep. Charles Bruning Co, 1800 W Central Rd, Mount Prospect, Ill.

Circle 332, Reader Service Card

Electronic templets . . . that are pressure-sensitive, which reproduce extremities of electronic components to customers' dimensional requirements, can now be delivered within 48 hr of receipt of approved artwork. Can be made to any size, to military or commercial specifications. Removable slit liner enables user to expose only half the pressure-sensitive surface while positioning it on layout. Flexigraph Co, 998 Farmington Ave, West Hartford, Conn.

Circle 333, Reader Service Card



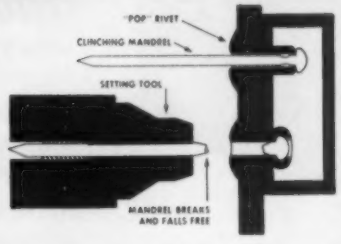
Pocket-size slide rule . . . adds and subtracts fractions and decimal equivalents in calibrations to 64ths. Vertical slide calculator also shows all combinations that make up any given answer at any setting. Directions are printed on face. All calibrations are permanently etched in frosted aluminum plates that are laminated onto a rigid, non-breakable white lucite mounting. Comes in tan vinyl case. Seymour Co, 701 W Sheridan Rd, Chicago 13.

928-AB6

Circle 334, Reader Service Card

"POP" RIVETS

Assemble finely finished wood chair panels, enameled or painted metal sheets, "POP" Rivets save the surface. Setting tools can't slip. Burrs on fastener head and countersinking are eliminated.



HOW THEY WORK — "POP" Rivets are assembled on a precision high-tensile mandrel. Mandrel head is drawn into the reverse side of rivet with a setting tool. Mandrel head breaks off under tension clinching the rivet. Work is squeezed by compression — controlled radial expansion. Setting tools from $18 to $300.

"POP" Rivets set by compression without the turning action which tears the surface finish allowing corrosion to start. Fasten sheets as thin as .020 dead soft aluminum or 24 gauge steel without distortion. Use thinner materials without creating a fastener problem.

"POP" Rivets install and set from same side. Get this design advantage for your product. Set up to 1,000 an hour with unskilled help. 50% savings in installed fastener costs suggest your immediate investigation.

"POP" RIVET DIVISION
UNITED SHOE MACHINERY CORPORATION
RIVER ROAD, SHELTON, CONN.
REgent 5-3391

UNITED "POP" RIVETS

MIDGET MUFFLERS Ready!

M-1 ONLY $1.95

Sensational!

Industry's handiest new devices! They're made from polyether foam enclosed in anodized aluminum — they silence noises caused by exhausting air. Rust-proof; common solvents clean 'em! Use M-1 or 2 for 1/8" or 1/4" exhaust ports; M-3 for 3/8" port. Order your Mead Midget Mufflers direct or send for name of nearest Mead Distributor.

Prices slightly higher West and Canada

M-2 $1.95

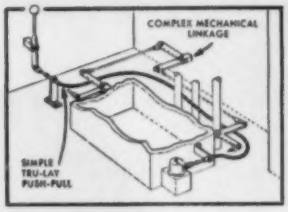
M-3 $2.50

MEAD SPECIALTIES COMPANY

4114 N. Knox Ave., Dept. PE-99 Chicago 41, Ill.

CIRCLE NO. 206 READER SERVICE CARD

TRU-LAY PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY AND IMPROVE DESIGN



Push-Pull remote controls, shown here, are flexible, have but one moving part, and give a lifetime of accuracy. Mechanical linkages are complex, are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.

This Push-Pull Data File—containing 7 engineering bulletins—will show you how these flexible controls have eliminated mechanical linkages on hundreds of products. You can make *your* products more useful, easier to sell, with Push-Pull controls. Write for your Data File today.

Automotive and Aircraft Division
AMERICAN CHAIN & CABLE

ACCO

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CIRCLE NO. 207 READER SERVICE CARD

'Set' for greater Serviceability and Saleability....

with the lasting color beauty and textured finish of

Masland Duran® Clad

VINYL LAMINATED TO METAL

Unlimited design opportunities are opened up by this versatile, semi-rigid vinyl surfacing. Combining practical engineering with high-fashion beauty, it provides a "built-in" finish that remains unimpaired throughout processing operations. Even shearing, crimping, punching or drilling won't damage texture or color. Many distinctive, easy-to-clean colors. For real competitive advantages put Masland Duran Clad in your product design plans.

THE MASLAND DURALEATHER CO., Dept. PE
Amber and Willard Sts., Philadelphia 34, Pa.

Please send folder and samples of Masland Duran Clad:

NAME_____ TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE_____ STATE_____

Masland Duran **CLAD** vinyl surfacing

Industrial Products Division
THE MASLAND DURALEATHER CO.
Dept. PE, Amber and Willard Sts., Philadelphia 34, Pa.

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 93.

WELDED BELLOWS DESIGN—Manual and slide rule, 20 pp. Manual contains advanced mathematical formulas to compute reasonable design parameters for welded metal bellows, for such uses as volumetric expansion devices, pressure sensors, rotary and linear seals. Belfab Corp, 914 Hobson Ave, Hamden, Conn.

Circle 340, Reader Service Card

TITANIUM MACHINING—Manual, 32 pp. Outlines do's and don'ts for successful machining of commercially pure and alloy grade titanium. Tabular data is arranged so that recommendations can serve as working guides. Titanium Metals Corp of America, 233 Broadway, New York 7.

Circle 341, Reader Service Card

BASIC CIRCUITS—Booklet, pocket-sized, 32 pp. Illustrates basic relay combinations as a guide to available circuits and their components. Also offered is relay and switch templet. Automatic Electric Co, Northlake, Ill.

Circle 342, Reader Service Card

RETAINING RINGS—Specification manual, 40 pp. Contains application illustrations as well as information on selection of materials, finishes, design factor, charts on rotative speeds and thrust loads and typical layouts for both internal and external ring applications. Retaining Ring Div, Ramsey Corp, Dept PR, 3693 Forest Park Blvd, St Louis 8.

Circle 343, Reader Service Card

SELF-LUBRICATING PACKINGS—Catalog and price list, SLP-659, 12 pp. Discusses packings, their advantages and applications on pump rods and shafts and valve stems. 29 types are illustrated and described. Greene, Tweed & Co, N Wales, Penna.

Circle 344, Reader Service Card

COMPENSATED RADIATION DETECTORS—Catalog C93-1a, 29 pp. Theory and fundamentals of radiation pyrometry as well as function, construction and application of compensated radiation detectors. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne & Windrim Aves, Philadelphia 44.

Circle 345, Reader Service Card

THERMOCOUPLES—Catalog EN-S2, 52 pp. Lists and describes standard assemblies in protecting tubes and wells for general applications; specialized thermocouples and assemblies; and line of thermocouple components and accessories. Leeds & Northrup Co, 4934 Stenton Ave, Philadelphia 44.

Circle 346, Reader Service Card

METERS—Catalog, 20 pp. Covers expanded scale ac and dc voltmeters, expanded scale frequency meters and linear scale ammeters, each presented individually with information ranging from operating principles through specifications. Helipot Div, Beckman Instruments Inc, 2500 Fullerton Rd, Fullerton, Calif.

Circle 347, Reader Service Card

ELECTROMAGNETIC CLUTCHES—Bulletin R-6304-1B, 20 pp. Provides design, specification and application material on clutches in six series with torque capacities from 1.8 through 13,000 lb-ft. I-T-E Circuit Breaker Co, 1900 Hamilton St, Philadelphia 30.

Circle 348, Reader Service Card

METAL O-RINGS—Design manual, 12 pp. Discusses function, operation, applications and design considerations. Includes installation information. Advanced Products Co, 59 Broadway, North Haven, Conn.

Circle 349, Reader Service Card

MOTOR-TACH GENERATOR—Catalog 6000, 16 pp. Lists and describes basic models of line of motor-tach generators, sizes 8 to 18. With performance curves, dimensional drawings, and physical, electrical and mechanical characteristics. Avionic Div, John Oster Mfg Co, 1 Main St, Racine, Wis.

Circle 350, Reader Service Card

AIR CONTROL VALVES—Bulletins 8100 and 8101, 4 pp each. Bulletin 8100 covers disk-type valves from ¼ through 1 in. pipe sizes and a line of pilot-operated valves from ½ through ¾ in. pipe sizes. Bulletin 8101 describes series of ⅛ through ¼ in. valves for direct actuation of small cylinders and for use as pilot valves in

(Continued on page 90)

GENERAL INDUSTRIES

Smooth Power

AC MOTORS

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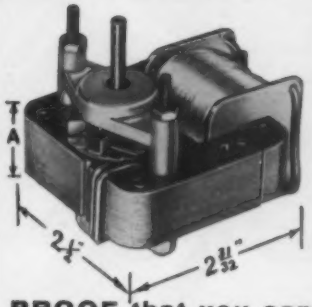

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A-3-CW A-3-CCW	1/500	0.7	1.1	3360	9/16"
A-4-CW A-4-CCW	1/350	1.0	1.4	3380	1/2"
A-5-CW A-5-CCW	1/180	1.7	2.7	3430	9/16"
A-6-CW A-6-CCW	1/130	1.9	3.3	3430	5/8"
A-7-CW A-7-CCW	1/100	2.1	3.8	3500	7/8"
A-8-CW A-8-CCW	1/90	2.5	4.5	3480	1"
A-9-CW A-9-CCW	1/70	2.7	5.3	3520	1 1/8"
A-12-CW A-12-CCW	1/60	3.0	6.5	3500	1 1/2"
A-14-CW A-14-CCW	1/50	3.1	7.0	3490	1 3/4"
A-16-CW A-16-CCW	1/45	4.0	7.5	3490	2"

Standard shaft diameter .1817, 1/4" shaft available if desired.

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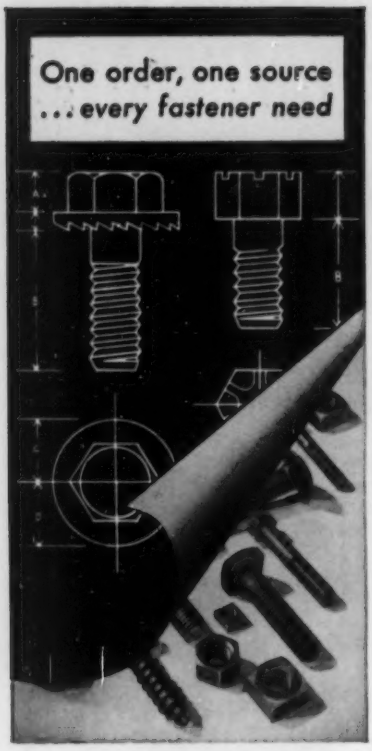

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Catalogs and Bulletins continued

sequence circuits. Cleveland Pneumatic Industries, 64 Old Orchard, Skokie, Ill.
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RUBBER PARTS—Bulletin AD-167, 6 pp. Describes various types of molded and extruded rubber parts. Categorizes available rubbers in six groups and gives descriptions and applications for each. Garlock Packing Co, 436 Main St, Palmyra, NY.
Circle 352, Reader Service Card

SIGHT GLASSES—Bulletin, 4 pp. Outlines recommendations to eliminate indiscriminate use of sight glasses in process equipment and includes alternate design solutions. Artisan Metal Products Inc, 73 Pont St, Waltham, Mass.
Circle 353, Reader Service Card

PRECISION POTENTIOMETERS—Six data sheets. Each sheet, one for each model, covers specifications, information on parameter, diagrams, resolution and power dissipation graphs and environmental test data. Guidance Controls Corp, 110 Duffy Ave, Hicksville, NY.
Circle 354, Reader Service Card

HIGH-SPEED COUNTER—Data sheet, 4 pp. Describes operation, uses and modifications available on line of high-speed, quick-reset, geared counters. Veeder-Root Inc, Hartford 2, Conn.
Circle 355, Reader Service Card

STAINLESS STEEL—Bulletin 109, 2 pp. Presents information on composition, performance and properties of RA309 (22 Cr-12 Ni stainless). Rolled Alloys Inc, 5309 Concord, Detroit 11.
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ELECTRONIC TIME DELAYS—Bulletin 5903, 8 pp. Contains description of circuit design, manufacturing and assem-
(Continued on page 92)

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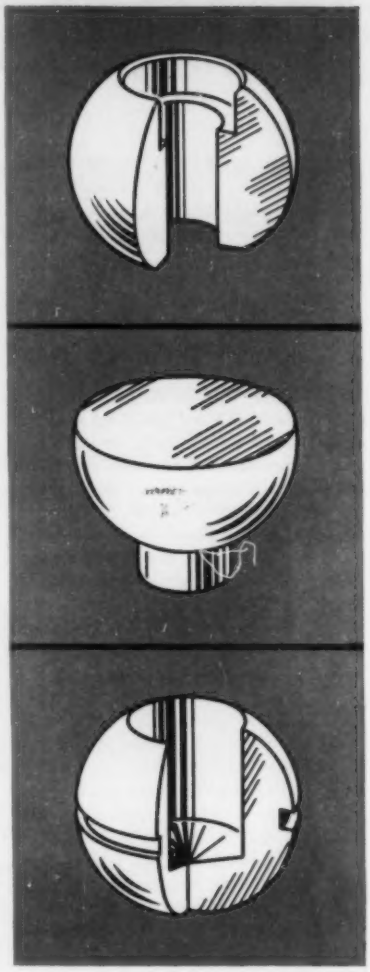

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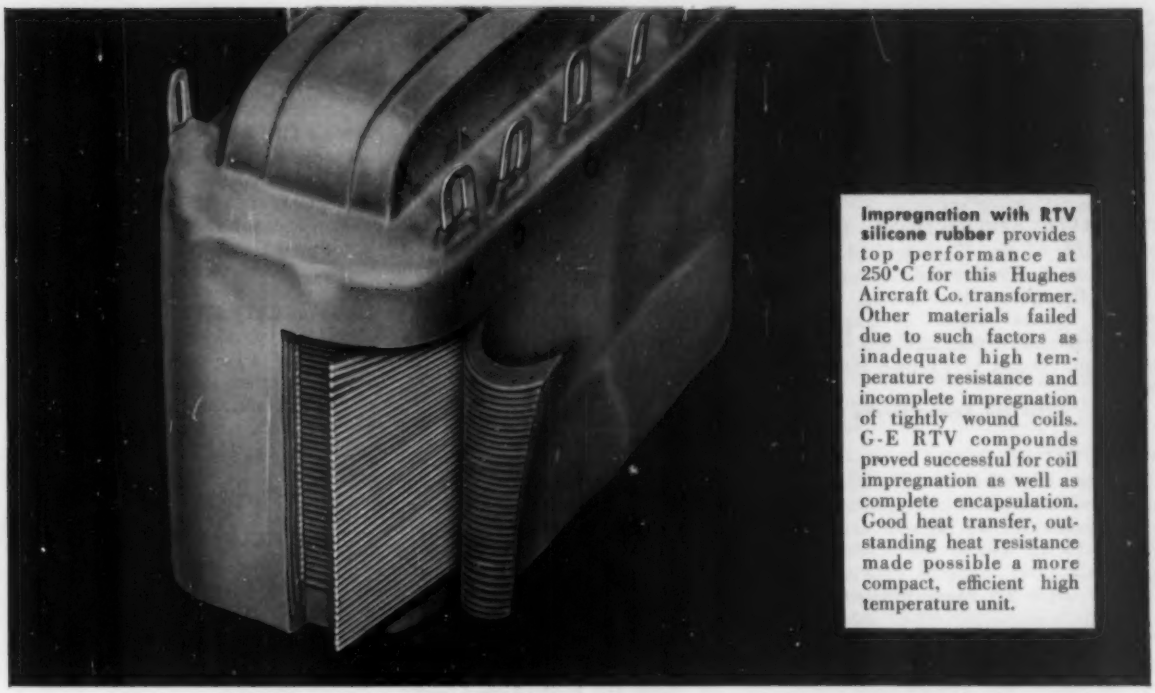

Impregnation with RTV silicone rubber provides top performance at 250°C for this Hughes Aircraft Co. transformer. Other materials failed due to such factors as inadequate high temperature resistance and incomplete impregnation of tightly wound coils. G-E RTV compounds proved successful for coil impregnation as well as complete encapsulation. Good heat transfer, outstanding heat resistance made possible a more compact, efficient high temperature unit.

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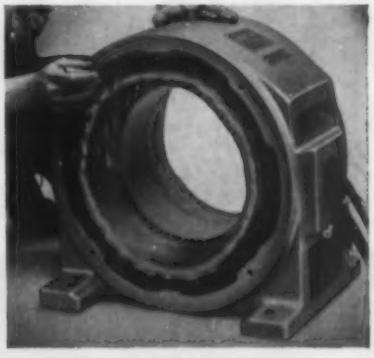
Outstanding heat resistance and electrical properties combined with room temperature cure

New resilient, shock-absorbent RTV sponge offers improved shock and vibration protection at elevated temperatures; permits easier fabrication than previous methods of cutting, inserting and sealing sponge in place. With RTV, just add sponging and curing agents to compound and mix.

Protection from high altitude arc-over and corona is provided for this cathode ray tube by encapsulating all lead wires with RTV (room temperature vulcanizing) silicone rubber. Designed for airborne operation and installed in a non-pressurized section of the aircraft, tube is protected from arc-over and corona at altitudes up to 70,000 feet.



Extended service life for motors through RTV encapsulation of stator windings, introduced by General Electric motor departments. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring totally enclosed units. RTV has low viscosity, rapid cure.

For application data and samples of General Electric RTV silicone rubber, write General Electric Company, Silicone Products Department, Section A98, Waterford, New York

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

Catalogs and Bulletins.....continued

bly process, standard and special specs, and information on sizes, mounting arrangements, weights and terminal styles for line of time delay relays. Tempo Instrument Inc, PO Box 338, Hicksville, NY.

Circle 357, Reader Service Card

PNEUMATIC APPLICATIONS – Booklet APP-88, 12 pp. 43 photos and case histories are used to show how air may do the job through use of air motors, compressors, vacuum pumps. 24 diagrams illustrate pneumatic principles used. Gast Mfg Corp, PO Box 117, Benton Harbor, Mich.

Circle 358, Reader Service Card

MAGNETIC STARTERS–Catalog 14-B1, 16 pp. Presents construction, ratings, operational information, and applications of redesigned line of magnetic starters through 15 hp, 440 to 550 v. Furnas Electric Co, 1050 McKee St, Batavia, Ill.

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FABRICATING PLEXIGLAS – Handbook, 34 pp. Describes material, enumerates applications and outlines characteristics. Includes discussion of design considerations. Profusely illustrated with cross-sectional drawings. Commercial Plastics & Supply Corp, 630 Broadway, New York 12.

Circle 360, Reader Service Card

WEIGHING SYSTEMS–4 fact folders. Cover basic art of weighing, accuracy in weighing systems, and instrumentation used. May be used for collection of competitive data, too. A H Emery Co, Pine St, New Canaan, Conn.

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HP NOMOGRAM–Dual nomogram for hp, torque and rpm applicable to fhp motors and transmissions gives two scales each for torque and for hp. Rpm scale from 0.5 to 500 rpm are given. Torques to 300 in.-lb are on one scale; to 600 ft-lb on other. Merkle-Korff Gear Co, 213 N Morgan, Chicago 7.

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TUBE SELECTOR–Folder, 4 pp. Lists, with applicable specifications and typical uses, expanded line of tube mill products. Scovill Mfg Co, 99 Mill St, Waterbury 20, Conn.

Circle 363, Reader Service Card

AUTOMATIC CLUTCH–Catalog sheets and price list, 6 pp. Specifications, design and application information on line. V-Plex Clutch Corp, 550 W Main St, Hagerstown, Ind.

Circle 364, Reader Service Card

GASKETING–Bulletin, 4 pp. Discusses properties and potential uses of TFE-fluorocarbon impregnated felt gaskets. Includes table of physical properties. DuPont Fabrics Div, E I Du Pont de Nemours & Co, Fairfield, Conn.

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HEAT-TREATMENT OF STEEL–Brochure, 28 pp. Describes derivation and meaning of TTT diagram and provides basic information about heat-treating. Includes TTT diagrams for commonly-used grades of SAE tool steels. Uddeholm Co of America Inc, 155 E 44th St, New York City.

Circle 366, Reader Service Card

VALVED COUPLINGS–Catalog 280B, 4 pp. Cutaway drawings, dimensional data and selections of end threadings for six sizes of couplings are included. Various accessory items are illustrated and detailed. Snap-Tie Inc, Union City, Penna.

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REGULATORS, FLOW CONTROL – Bulletin 91021, 8 pp. Describes pressure regulators, strainers, flow control valves,

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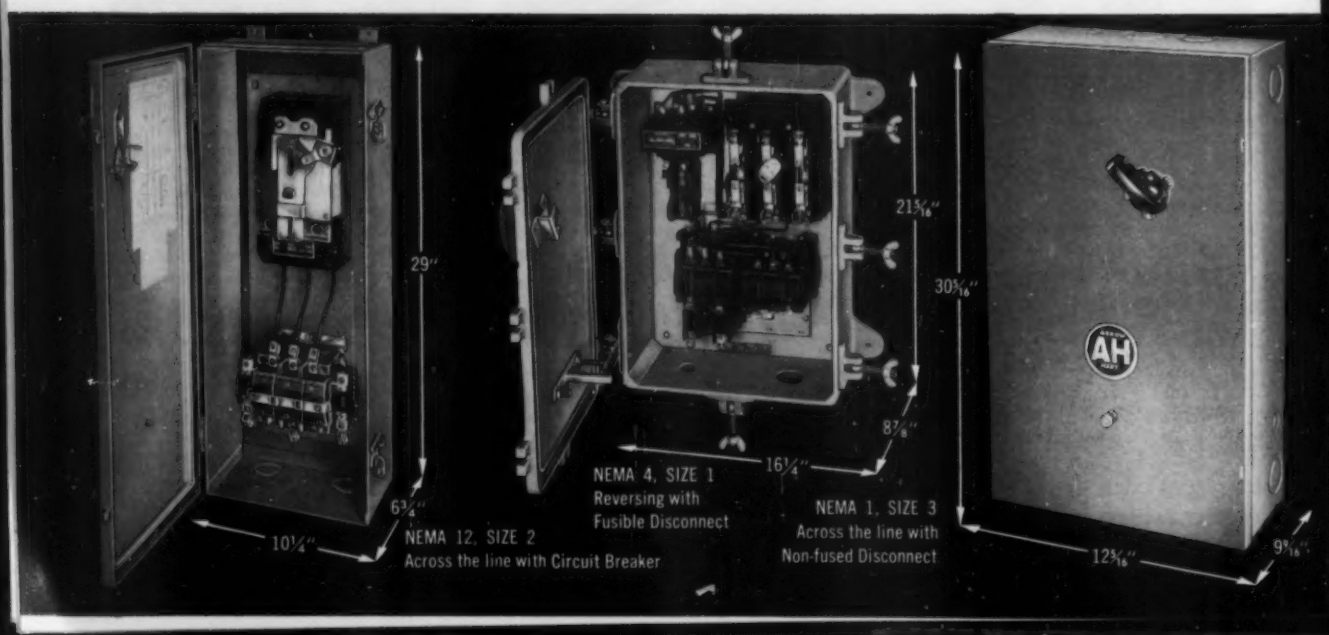

sequence valves and quick exhaust valves. Supplies specs, features, dimensions and ordering information. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

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MOTORS AND GENERATORS—Brochure, 6 pp. Covers electric ac and dc motors and generators—motors from 1 to 200 hp; motor-generator sets from ½ to 150 kw. Imperial Electric Co, 84 Ira Ave, Akron 9.

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LIGHTED PUSHBUTTON PANEL SWITCHES—Brochure 55, 4 pp. Describes series of switches for computers, office machinery, machine tool control and instrument panels. Combines lighting, legend and switching. Includes two new models, specs and dimensional information. Electrosnap Corp, 4218 W Lake St, Chicago 24.

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PRECISION INSTRUMENT COUNTERS—Catalog sheets, 4 pp. Describe, illustrate and show dimensional drawings of series 1000 and 2500 instrument counters. Chicago Dynamic Industries Inc, Precision Products Div, 1725 Diversey Blvd, Chicago 14.

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GAS REGULATORS—Brochure, 4 pp. Specifications and applications of LP-gas and natural gas regulators, 2 to 500 hp. Beam Products Mfg Co, Los Angeles.

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EXPANDABLE POLYSTYRENE INSULATION—Bulletin C-9-271, 6 pp. Illustrates refrigerating and air-conditioning applications of material. Charts and pictures highlight insulating uses. Lists typical properties. Plastics Div, Koppers Co Inc, 801 Koppers Bldg, Pittsburgh 19.

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PRODUCTS LISTING—Bulletin D400, 8 pp. Contains general information on properties and uses of thermosetting phenolic and diallyl phthalate molding compounds, fire-retardant polyester resins for reinforced plastics and phenolic resins for bonding and coating. Durez Plastics Div, Hooker Chemical Corp, N Tonawanda, NY.

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SILICONE RUBBER COATED FABRICS—Data sheet, 2 pp. Description and typical properties of stock item silicone rubber coated fabrics. Connecticut Hard Rubber Co, 407 East St, New Haven 9, Conn.

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PRESSURE SCANNER—Bulletin 110, 2 pp. Describes and covers specifications and dimensions of electromechanical pressure scanner that scans up to 160 individual pressures with only 16 transducers. Datex Corp, 1307 S Myrtle Ave, Monrovia, Calif.

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Letterhead Requests Only

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

AUTOMATIC CONTROLS STANDARD—Tentative draft ASA C85, 68 pp. Proposed standard on terminology for automatic controls is available for criticism and comment. Frank Philippbar, Standards Manager, American Society of Mechanical Engineers, 29 W 39th St, New York 18.

WIRE AND CABLE TERMINOLOGY—Booklet, pocket-sized, 52 pp. Lists, alphabetically, common terms, expressions and units used in electrical wire and cable industry. Standard Wire & Cable Co, 3440 Overland Ave, Los Angeles 34.

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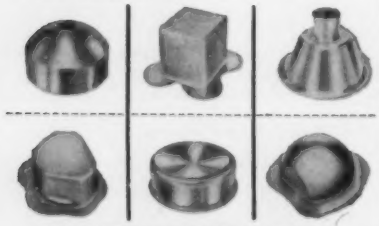

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Ballbearing Tests
Combined reprint: test methods for torque, vibration and runout, Sept. 14; devices to check preload and play. Sept 28
Circle P 10

Specifying Anodized Aluminum Finishes
Practical guide to ways that will give the specific coating needed. Sept 28
Circle P 9

13 Ways to Cut Drafting Costs
List of helpful modern methods, materials and equipment that save money. Sept 28
Circle P 8

Fixed-Resistors
Three-step method chooses type and rating for power and control. Sept 28
Circle P 7

More Engineering per Engineer
Review of new techniques designed to reduce the noncreative load on engineers. Sept 21
Circle P 6

Equipment Says it in Color
How eye-catching color code conveys information from machine to operator. Sept 14
Circle P 5

New Data for High-Pressure Air
Properties of air under pressure. Curves useful from 0 to 12000 psi and —150 to 250 F. Sept 14
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Latest in Slip Clutches
Describes two new designs, one of them a dual-spring type. Aug 31
Circle P 3

What Is Creativity
Latest methods for measuring, controlling and stimulating creativity in R&D. Aug 24
Circle P 2

Porcelainized Cast Aluminum
How low-temperature fits may be applied to permanent-mold castings and sheet aluminum. Aug 17
Circle P 1

Liquid Spring Saves Space
What it can do and how to use it. Aug 17
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Fiberglass Sleeve Springs
Their high energy-absorbent characteristics are shown by charts and equations. Aug 17
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(Continued on page 96)

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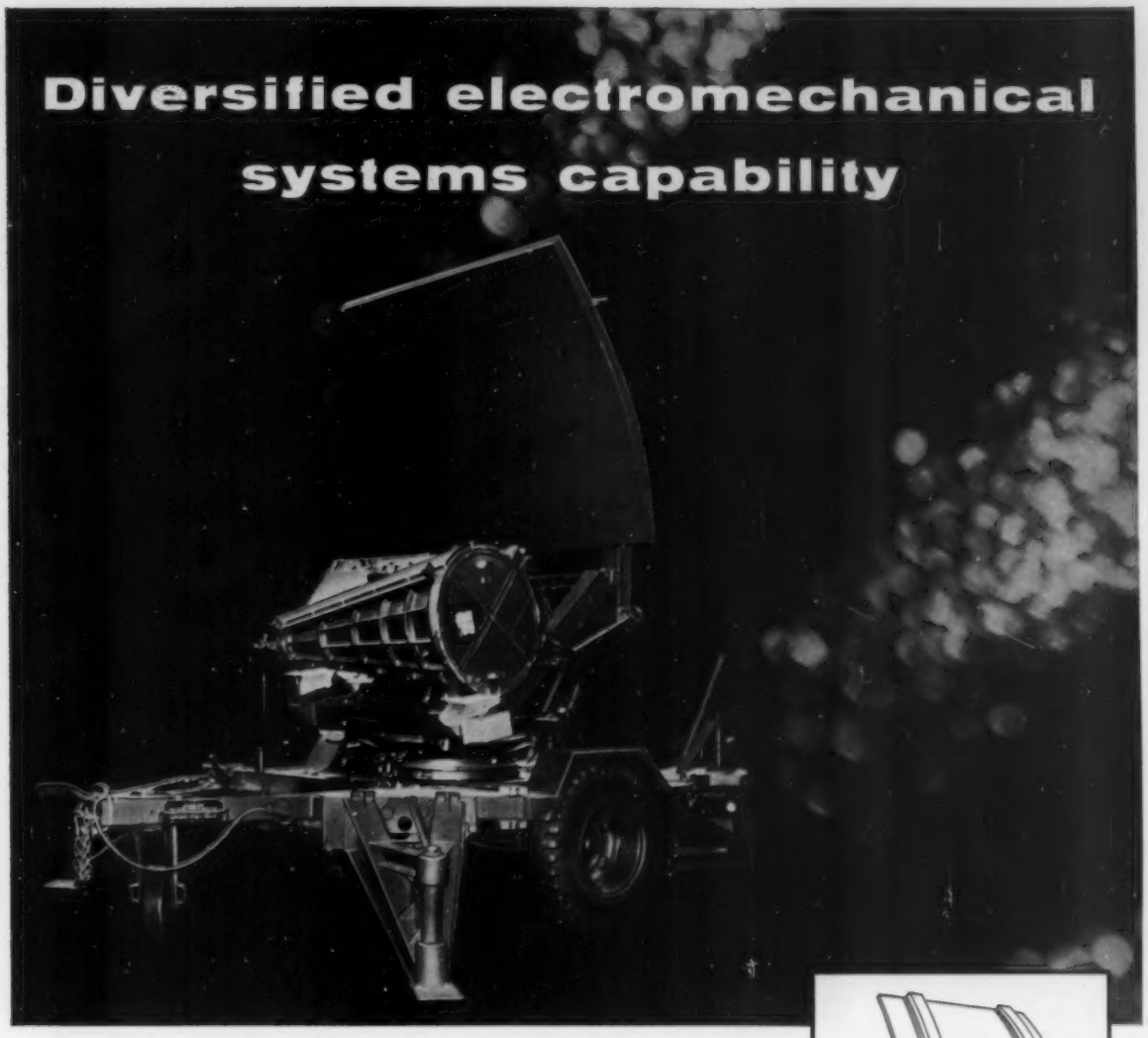
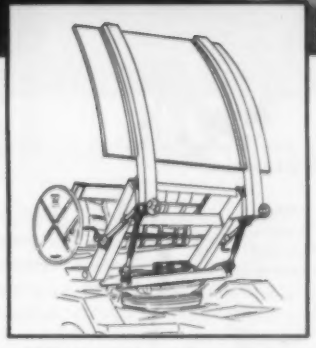


AiResearch Actuation Systems For Portable Radar represent a typical electromechanical systems application in ground support equipment. Two types of AiResearch actuation systems are now in production for the Army's mobile trailer-mounted ground radar unit. They consist of a manually operated antenna folding storage system and an electrically powered antenna elevation system.

Designed to operate under the most severe environmental conditions, this type of electromechanical system can operate on 60 cycle A.C., 400 cycle A.C., or 28 volt D.C. Other suggested applications include: *missile launchers, missile ground handling and support equipment, armored vehicle fire control and ballistic handling systems, and mobile communications equipment requiring servoed actuating systems.*

AiResearch leadership in the development and production of electromechanical equipment for aircraft, ground handling, ordnance and missile systems of all types also includes such recent examples as spoiler servo control systems, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting. We invite you to submit a problem statement of your electromechanical requirements.



U.S. Army Signal Corps ground portable radar unit operated with two AiResearch electromechanical actuation systems.

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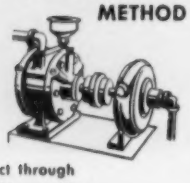
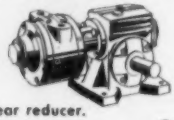


Direct through flexible coupling.



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9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

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For vibration problems, these isolators can outperform the more popular "viscous" type. Aug 3 Circle E 96

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This important new technique analyzes stress by ultrasonics. July 20 Circle E 94

Friction Drives
Floating idlers give proper pressure between steel shafts for vibrationless drive. Equations show how to apply them. July 6 Circle E 92

Four Ways to Stop a Motor
They range from mechanical to capacitor braking for an induction motor; table shows limitations of each. July 6 Circle E 91

Experiments, with Statistical Certainty
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Hint: To insure maximum operating efficiency for *your* machinery, check the above photograph. It shows the contact tips (at right) from a Clark Type "CY" A-C Motor Starter after one year of continuous service with frequently as many as 5,000 operations per hour. Compare them with the new, unused tips at left above.

See for yourself that except for slight discoloration and minute pitting the used contact tips show very little evidence of wear even after one year of steady operation. Many more years of reliable, maintenance-free (and downtime-free) service are assured.

Clark's exclusive "arc quenching" principle, which works through the use of strong, multi-turn magnetic blowouts and double-break contacts, is the answer.

The action of the magnetic field not only forces the arc to rotate, moving it continually over contact surfaces, but tends to "quench" it at the same time. As a result, there's less wear on contact tips and a substantial reduction in maintenance requirements – much less machine downtime.

There are many more good reasons why the Clark Type "CY" Starters will control your machines better – help them to put their "best foot forward" and keep it there. For *all* the facts on Clark "CY" Starters, as well as space-saving "PM" Relays and other controls in Clark's "standard of quality" line contact your nearest Clark Controller sales office or distributor. Or, write direct.

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DESIGN ABSTRACTS

Acoustic Fatigue Characteristics of Aluminum Panels

Panels 11x13 in. of 2024-T3 aluminum were exposed to discrete noise from a siren and random noise from an air jet, with noise levels varying from approximately 140 to 161 db. Panel variables included thickness, edge condition, curvature, static pressure differential.

Differences in failure times are given as a function of noise level and panel thickness, curvature and static pressure. Feasibility of locating weak points in panels by this means and of predicting fatigue life are discussed.

"A Study of the Acoustic Fatigue Characteristics of Some Flat and Curved Aluminum Panels Exposed to Random and Discrete Noise," Hess, Herr and Mayes, Langley Research Center, NASATN D-1. National Aeronautics and Space Administration, Washington 25, DC.

Impact Fatigue Strength

Experiments which yielded differences between impact fatigue strength and ordinary fatigue strength values are described, and effects of varying diameters of test bars given. Data on scale factor for low vs high-temperature tempered specimens is also included.

"Study of Impact Fatigue Strength," N N Davidenkov and E I Belyayeva, Transactions of Metalovedenize i Abrabotka Metallov, April 1959, USSR. Translation available from Henry Brutcher, PO Box 157, Altadena, Calif.

Continuous Blow-forming of Extruded Tubing

Polyethylene tubing is extruded up and through pinch rolls and guide plates which control inflation to produce variations in diameter up to 10 times that of uninflated tube. Typical blown shapes are illustrated, as well as takeoff and forming mechanism. Principles and limitations are discussed.

"Continuous Blow-forming of Extruded Tubing," T Kasahara, Polymer Industrial Co, Ltd, Tokyo, Japan. Modern Plastics, Aug 1959, 575 Madison Ave, New York 22.

Photoelectric Cell for Measuring

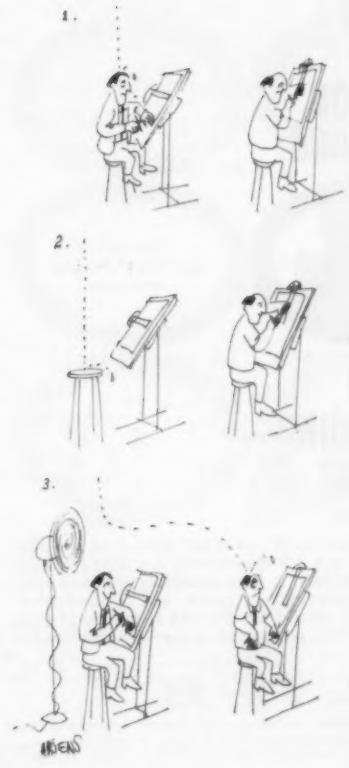
Applications and design of cells are discussed and an extensive bibliography provided. Topics covered include galvanometric measurement, photometry with unanalyzed light, spectral photometry and calorimetry, absorption and blackening measurements, polarimetry and optical crystallography.

"The Photoelectric Cell as a Measuring Instrument," Rudolf Sewig. Transaction of Zeitschrift fur Instrumentunde (West Germany). Translations available from Special Libraries Assn Translation Center, John Crerar Library, 86 E Randolph St, Chicago 1.

Producing Special Properties in Epoxies with Fillers

How fillers such as silica, mica, calcium carbonate, zirconium silicate, powdered metals can effect insulating qualities, shrinkage rates, thermal expansion, heat dissipation, self-extinguishing characteristics, resin viscosity, foam density of epoxy resins.

"Producing Special Properties in Plastics with Fillers," Formo and Isleifson, Minneapolis-Honeywell Regulator Co. SPE Journal, Aug 1959, 65 Prospect St, Stamford, Conn.



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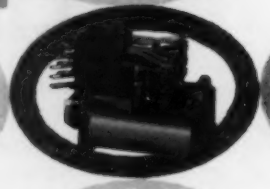

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NEW BOOKS

Introduction to Stress Analysis

CHARLES O HARRIS. MacMillan Co, 60 Fifth Ave, New York 11. 6 x 9, 339 pp, $7.50.

Title of this text might be slightly misleading to engineers as it is not on experimental stress-analysis techniques but on the subject generally termed "strength of materials." In all fairness to the author he does point this out in the preface and justifies his selection of the title by stating that courses (and texts) on the subject of "strength of materials" have never been what the name implies (i.e. on the strength of the material itself). But one might say that the title of this text also is not accurate as the subject is more on strength of configurations such as beams, columns, tubes, plates, shells, etc.) rather than on the analysis of distribution of stresses.

Aside from this minor criticism, the author has put across a well-balanced text, covering most of the fundamental concepts in this field. He does make extensive use of methods of synthesis and superposition, and has an interesting short chapter on elementary plasticity.

Translations: Services and Sources

Edited by FRANCES E KAISER, Georgia Institute of Technology. Special Libraries Association, 31 E 10 St, New York 3. 60 pp, 8 x 11. $2.50.

This directory lists the services, rates, languages, subject specialties, addresses, telephone numbers and other pertinent facts about 154 translators in the US. One section "Pools of Translations," lists organizations and societies which gather and maintain translated material. 83 references to published bibliographies of translations form Part 3.

Principles of Direct-current Machines

ALEXANDER S LANGSDORF. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 6 x 9, 363 pp. $8.50.

This sixth edition, a completely new version, presents a compact anal-

(Continued on page 101)

ysis of the operating characteristics of dc generators and motors based on the necessary relations between the magnetic and electrical circuits which constitute their structural design. The basic principles of electromagnetism are in the opening chapter, together with a full discussion of the systems of units in which magnetic and electrical quantities are expressed. The remainder of the book is concerned with the properties and construction of the machines themselves.

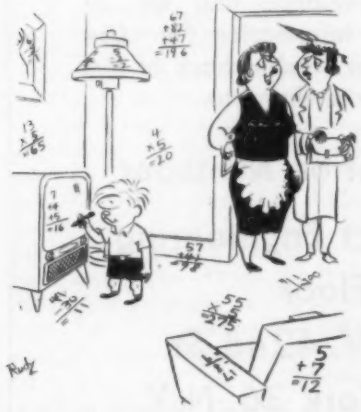
Major topics covered are: armature windings, excitation of the main field, armature reaction, generators, motors, control, rating, heating, commutation, special machines and freehand flux plotting. Appearing for first time in textbook form is a section on unipolar generators.

Refractories for Seal and Bearing Applications

PB 151483, Sibley et al, Battelle Memorial Institute (WADC Technical Report 58-299) Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 52 pp. $1.50.

A number of ceramic, cermet, and high-temperature alloy materials have been evaluated for corrosion resistance and for friction and wear behavior in an oxidizing atmosphere from 1000 to 1800 F. Rubbing-wear experiments were conducted at 200 fps sliding speed with about 20 psi load pressure. Several material combinations involving an alumina-chromium-molybdenum cermet, silicon carbide, alumina, and perhaps a titanium carbide-nickel-molybdenum cermet may

(Continued on page 103)



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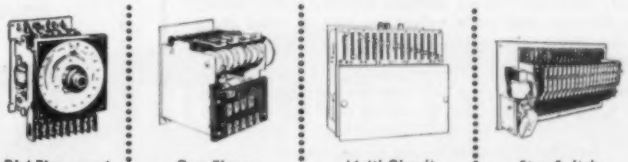

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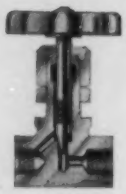

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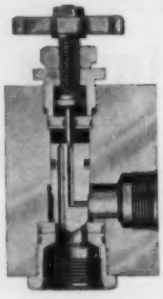

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be satisfactory for short-life rubbing-seal use under these particular conditions. A wear-failure mechanism for refractory materials under sliding contact is postulated, and some correlation of the experimental results with conventional thermal-stress-resistance parameters is obtained. Full title: "A Study of Refractory Materials for Seal and Bearing Applications in Aircraft Accessory Units and Rocket Motors".

Yardsticks for Industrial Research

JAMES BRIAN QUINN. Ronald Press Co, 15 E 26th St, New York 10. 6¼ x 9¼, 224 pp. $6.50.

How do you evaluate the importance of a research effort in a profit-motivated company? Here is a survey of current thought on the subject. The material has been extracted from literature and from extensive interviews with research directors, most of whom are associated with large electronic and chemical firms. The author is concerned primarily with four aspects of the problem: the economic evaluation of fundamental research, defensive research, and offensive research, and the technical evaluation of all research. (Offensive research develops technology for exploiting new markets; defensive research defends a company's position in existing markets.) Also included is a discussion of current methods for evaluating the management of a research and development program.

Physical Properties of Polymers

Society of Chemical Industry (British), Monograph No. 5. Macmillan Co, 60 Fifth Ave, New York 11. 9 x 6, 293 pp. $6.

Collected in this monograph are 20 short papers dealing with the physics of some of our most useful plastics—polyethylene, polypropylene, melamine, PVC and others. Some of the more interesting papers for the design engineer deeply involved with the properties of plastics include: "Impact Strength of Tough Plastics," Mechanical Properties of Plastics at Very Low Temperatures," "Coefficient of Friction and Dynamic Properties of PVC," and "Electrical Tracking Testing." Included at the back of each paper are sharp questions

(Continued on page 104)

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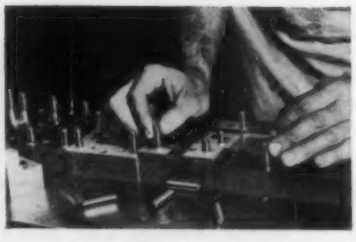

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by conference participants and the authors' answers, both of which add considerable depth to the reader's understanding of each subject. For the plastics specialist.

Aircraft Structural Metals and Joints at Elevated Temperatures

LUKE A YERKOVICH, Cornell Aeronautical Lab Inc. PB151445, Part IV (WADC Technical Report 54-270), 8½ x 11, 96 pp. $2.50. PB151561, Part V, 8½ x 11, 84 pp. $2. Office of Technical Services, Dept of Commerce, Washington 25, DC.

This 2-part report (full title: "Investigation of Compressive, Bearing and Shear Creep-rupture Properties of Aircraft Structural Metals and Joints at Elevated Temperatures") is loaded with useful high-temperature creep-rupture data in tention, compression and shear. Materials are limited to aircraft structurals, and so make the report less significant for design in general, but these aircraft materials and techniques of using them have always had a way of filtering down to the design of more mundane things. The report is an even more significant contribution to design because it studies the same material properties for particular joint configurations. How to design for compressive loads is covered by the same competent author in PRODUCT ENGINEERING, Dec 9 '57, p 72.

Other Books of Interest

Electric Utility Industry: U. S. Statistics for 1958

No. 59-122. Edison Electric Institute, 750 Third Ave, New York 17. 8¼ x 11, 73 pp, $1.50.

Fundamentals of Physical Science

Krauskopf. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36, NY. 6½ x 9½, 653 pp, $6.95.

A college text.

Industrial Building Details

Duane F. Raycraft. F W Dodge Corp, 119 W 40th St, New York 18. 9 x 11¾, 352 pp, $12.75.

This reference book for architectual purposes may interest engineers whose products are affected by the design of the buildings which will be used to house them.

Radioisotopes for Industry

Rochlin and Schultz. Reinhold Publishing Corp, 430 Park Ave, New York 22. 5¼ x 7½, 190 pp, $4.75.

Handbook of Preferred Circuits

Navy Aeronautical Electronic Equipment,

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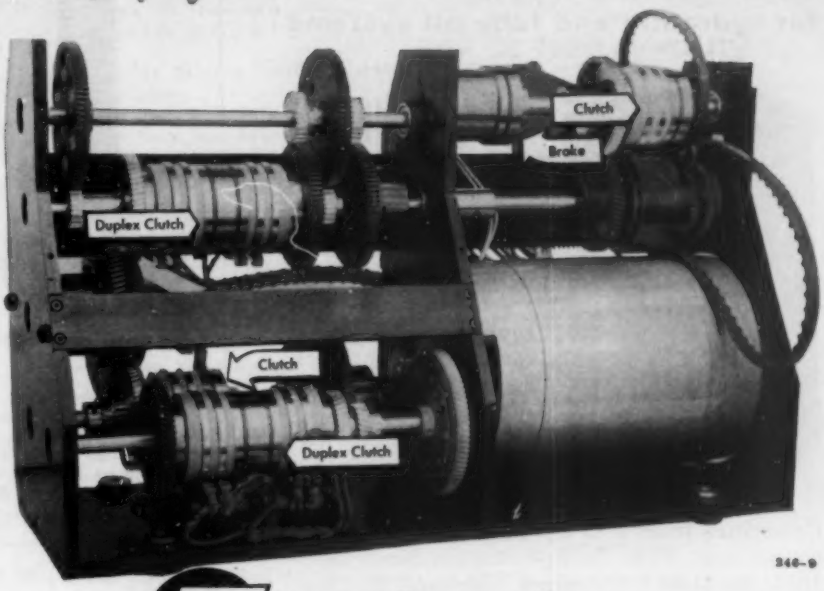

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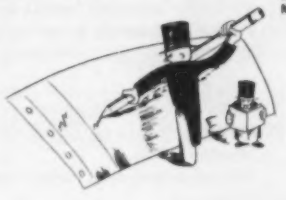

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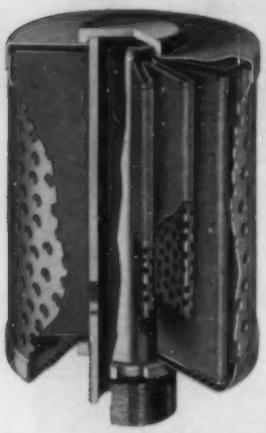

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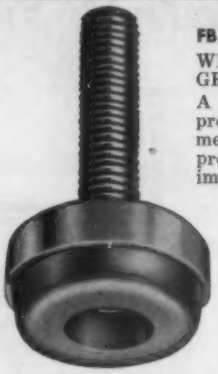

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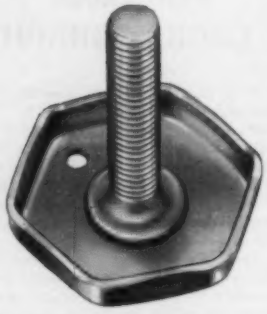

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NAVAER 16-1-519, Supplement No. 1. National Bureau of Standards. Superintendent of Documents, US Government Printing Office, Washington 25, DC. 7½ x 10¼, 106 pp, 60¢.

Molecular Science and Molecular Engineering

Arthur R. Von Hippel. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 8¾ x 11¼, 446 pp, $18.50.

The book ranges from material on atomic and molecular physics to discussions on how these studies have been applied to materials engineering, including some of the newer plastics and metal alloys.

Aviation Facts and Figures

1959 Edition. Modley, Hincks, Smith, Arnow. American Aviation Publications, Inc, 1001 Vermont Ave, NW, Washington 5 DC. 5¾ x 8¾ 147 pp. $2.

Continuous Analysis of Chemical Process Systems

Sidney Siggia. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6 x 9¼, 381 pp, $8.50.

Labor-Management Relations

Charles Wiedemann. Reinhold Publishing Corp, 430 Park Ave, New York 22. 5 x 7½, 142 pp, $3.75.

ASTM Standards on Petroleum Products and Lubricants

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6¼ x 9¼, 1210 pp, $6.

Metal Stampings—American Drafting Standards Manual

American Society of Mechanical Engineers, 29 W 39 St, New York 18. 8½ x 11, 22 pp, $1.50.

Compilation of ASTM Standards on Steel Piping Materials

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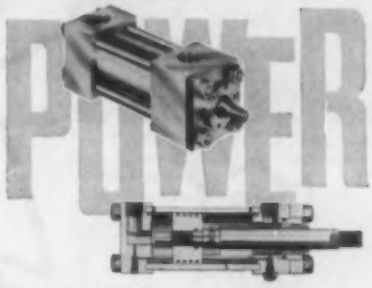

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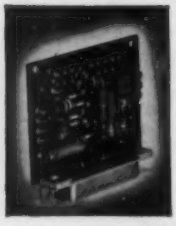

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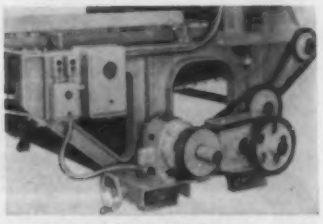

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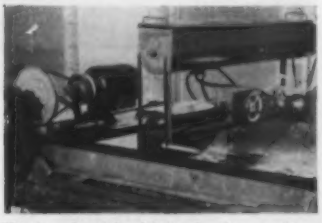

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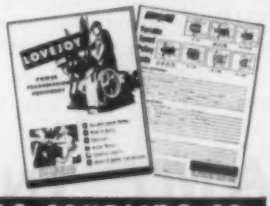

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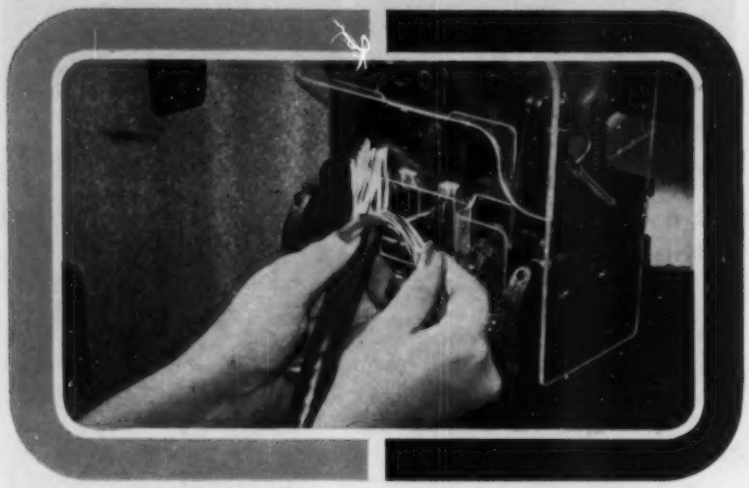

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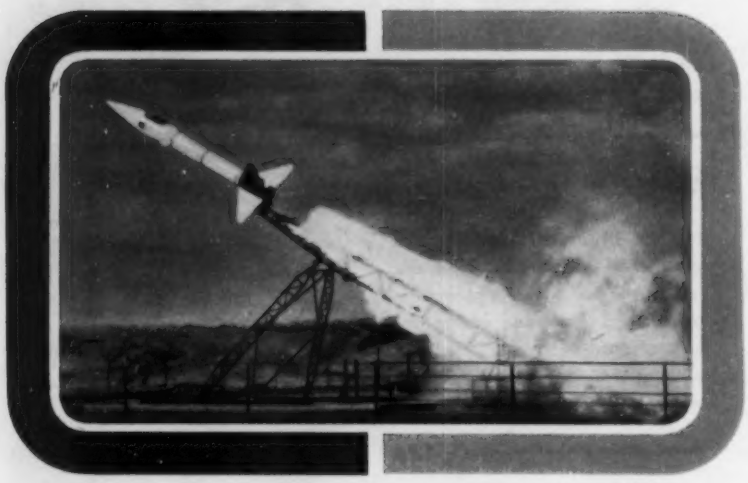

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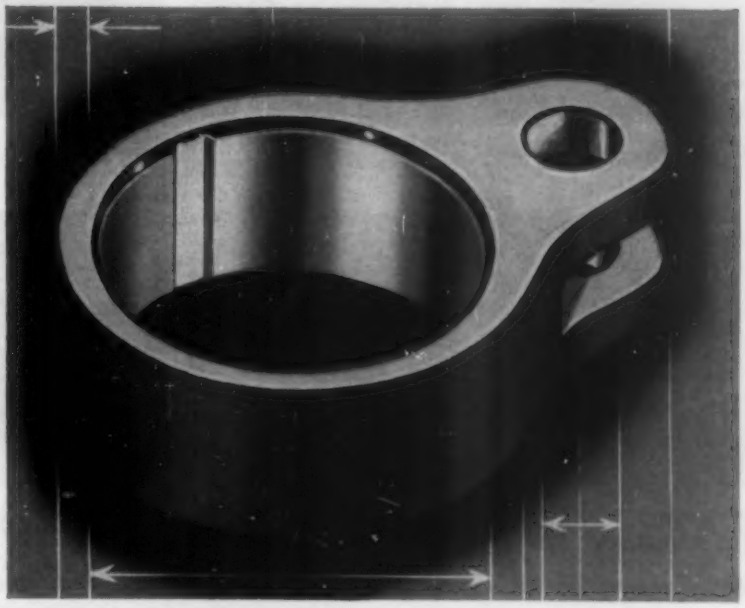

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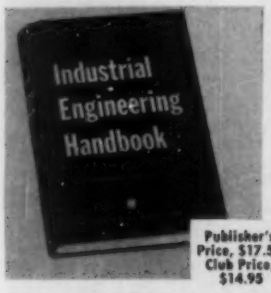

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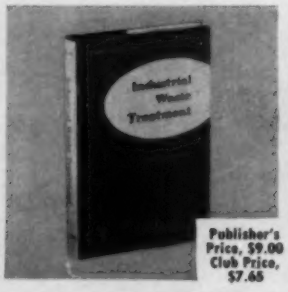

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P10—BALLBEARING TESTS—9/28/59

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
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19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
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REPRINTS

E84	E90	E91	E92	E94	E96	E97	E98	E99	E100
P1	P2	P3	P4	P5	P6	P7	P8	P9	P10

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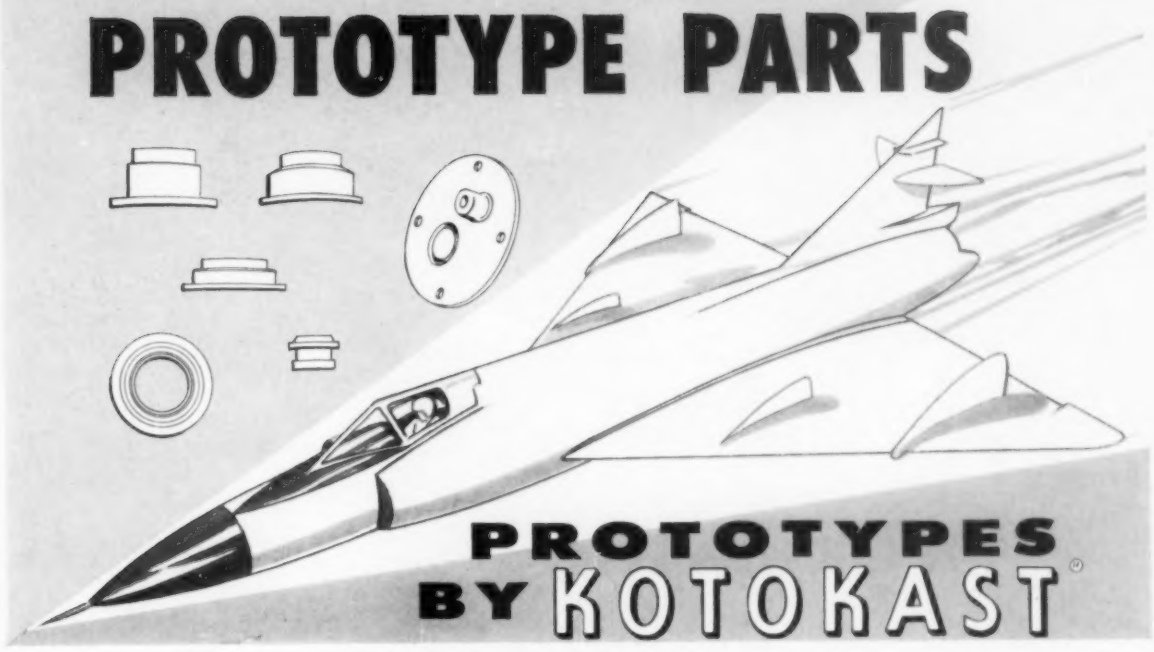

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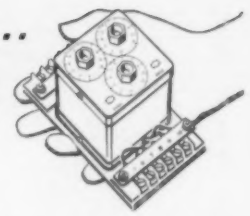
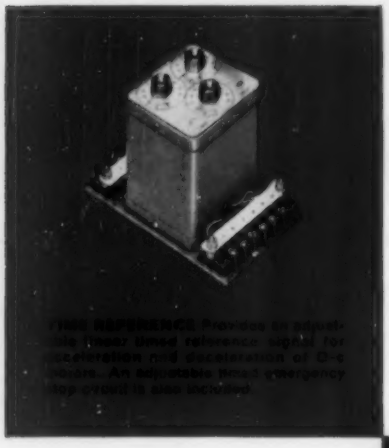
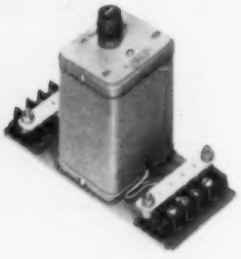


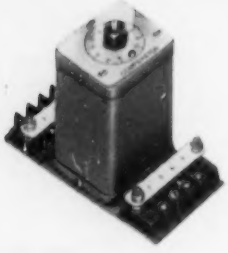


FINE REFERENCE Provides an adjustable linear timed reference signal for acceleration and deceleration of D-c motors. An adjustable time emergency stop circuit is also included.



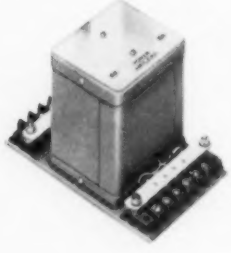
BIAS SUPPLY Provides static power conversion of A-c line voltage into two channels of D-c. This provides a bias voltage source for the other regulator modules when required.

To simplify the design and assembly of the regulating systems for the Ultraflex Adjustable Speed Packaged Drive, Cutler-Hammer developed a complete line of compact regulator modules. These units provide a new economical, time-saving "building-block" approach to the fabrication of speed regulators, current regulators, etc. All modules are static, transistorized, and encapsulated for maximum reliability and space-saving compactness. No electronic tubes are used. Terminal-board wiring between modules, front-adjusting potentiometers, and easy-access fuses are plus features that speed assembly operation and maintenance. Write today for the new descriptive Bulletin ED102-S249. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.



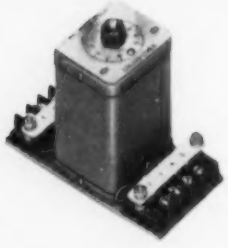
COMPARATOR This adjustable gain amplifier monitors a feedback signal, compares it with a reference input, then generates a corrective output error signal.

CURRENT LIMIT Designed to protect an armature circuit from over current, this module generates a corrective signal when the current reaches a pre-set limit. Current limit set point and taper are adjustable.

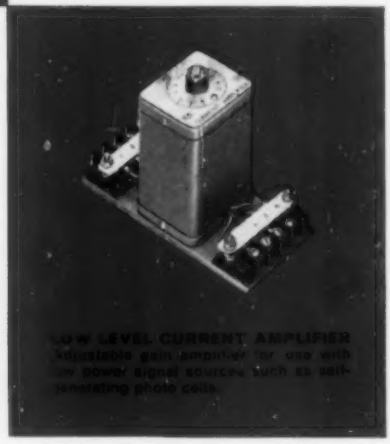


POWER AMPLIFIER Amplifies the output voltages from other modules when a stronger signal is required . . . frequently used as a pre-amp to magnetic amplifiers.

REFERENCE REGULATOR Converts an unregulated D-c input voltage into a regulated output suitable for use as a regulator reference voltage source.



CROSS-OVER Designed to progressively regulate both the armature voltage and shunt field excitation, the cross-over converts a single input into two output signals.



LOW LEVEL CURRENT AMPLIFIER Adjustable gain amplifier for use with low power signal sources such as self-generating photo cells.

CUTLER-HAMMER CONTROL C-H

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